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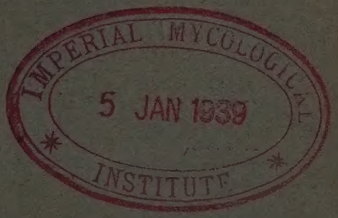

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TABLE DES MATIÈRES

Pages

MATHÉMATIQUES

F. I. Kharchiladze. Sur la représentation des fonctions par des intégrales singulières dans l'intervalle infini 339
M. Lavrentieff. Sur une classe de transformations quasi-conformes et sur les sillages gazeux 343

PHYSIQUE

Vs. Černjaiev. Determination of Rydberg Constants for Hydrogen and Deuterium 347
A. N. Filippov, J. Larionov and A. Seidel. On the Fluorescence of Solutions ot Salts of Cerium 351
L. E. Gurevich. The Problem of Electron Interaction in Metals 355
W. Antonov-Romanovsky. Influence of Temperature on Extinction of Phosphors 361

CHIMIE

A. V. Babayeva. Absorption Spectra of Complex Platinum Compounds . 365

GÉOCHIMIE

S. A. Borovick and T. A. Burova. On the Content of Rare Earths in the Kara-Tau Phosphorites 369
A. G. Titov. On a New Graphite Deposit in the Region of Krasnaya Polyana in North Caucasus 371
A. A. Saukov. A Nephelometric Method of Determining Small Quantities of Mercury 373

BIOCHIMIE

K. Ovcharov. On the Ferment of Pathogenic Fungi Causing the Splitting off of Urea from Protein 377
N. Maximov. Physico-Chemical Investigation of Cocklebur Oil 381

GÉOLOGIE

D. Sapozhnikov. On the Age of the Dzhezkazgan Series 383
G. E. Bykov. On the Question of Climates during the Quaternary Period of the Far East and on the History of Permanently Frozen Grounds. 387

MINÉRALOGIE

D. P. Grigoryev. Synthesis and Investigation of Biotite 391

GÉNÉTIQUE

H. F. Kushner. Investigation of the Blood Value of the Yaroslav Breed of Cattle with Reference to Productivity 393

PHYSIOLOGIE VÉGÉTALE

S. J. Rudenskaya. Development of the Latex Vessels System as a Factor of Rubber Accumulation in Kok-Saghyz Roots 399
A. F. Bibikova. Relation between the Structure of Tissues and Cold Resistance 405

Rédacteur en chef A. Fersman. Rédacteur S. Bernstein.

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MATHÉMATIQUES

SUR LA REPRÉSENTATION DES FONCTIONS PAR DES INTÉGRALES SINGULIÈRES DANS L'INTERVALLE INFINI

Par F. I. KHARCHILADZE

(Présenté par S. N. Bernstein, de l'Académie, le 17. V. 1938)

S. Bochner et S. Izumi (1) dans leur Note, récemment publiée, ont établi des conditions suffisantes pour que l'on ait la relation

$$\lim_{n\to\infty} n\int_{-\infty}^{+\infty} f(x+t)\,k(nt)\,dt = f(x)\int_{-\infty}^{+\infty} k(t)\,dt. \qquad (*)$$

Les auteurs supposent que la fonction $f(t)$ est continue au point $t=x$.

Cette Note est consacrée à la généralisation des résultats cités pour le cas, où $t=x$ est un point de Lebesgue, c'est-à-dire tel que

$$\lim_{h\to 0}\frac{1}{h}\int_{x}^{x+h} |f(t)-f(x)|\,dt = 0.$$

Nous allons d'abord citer sans démonstration deux lemmes, sur lesquels seront fondés nos raisonnements.

1. Lemme de I. Natanson (2). Soient $f(t)$ et $\psi(t)$ deux fonctions positives et sommables dans l'intervalle (a, b) et $\psi(t)$ une fonction décroissante. Alors

$$\int_a^b f(t)\psi(t)\,dt \leqslant 4\mu\int_a^b \psi(t)\,dt,$$

où

$$\mu = \sup_{0\leqslant h\leqslant b-a}\left\{\frac{1}{h}\int_a^{a+h} f(t)\,dt\right\}.$$

2. Lemme de Bochner et Izumi (1). Si nous posons:

1) $\int_a^b |g(t)|\,dt < +\infty, \quad (0<a<b<+\infty)$

2 $|H(t)| \leqslant M < +\infty,$

3) $\int_a^\infty \frac{|H(t)|}{t}\,dt < +\infty,$

alors nous avons:

$$\lim_{n\to\infty}\int_a^b g(t)\,H(nt)\,dt=0.$$

Théorème I. *Soit*

1) $\int_{-\infty}^{+\infty}\frac{|f(t)|^p}{1+|t|}\,dt<+\infty,\quad (p>1)$

2) $\int_{-\infty}^{+\infty}|t^{q-1}k^q(t)|\,dt<+\infty,\quad \left(\frac{1}{p}+\frac{1}{q}=1\right)$

3) *il existe une fonction* $k_1(z)$ *telle que*

a) $k_1(z)$ *croît pour* $z\leqslant 0$ *et décroît pour* $z\geqslant 0$,
b) $|k(z)|\leqslant k_1(z)$,
c) $\int_{-\infty}^{+\infty}k_1(z)\,dz<+\infty$,

alors la relation (*) *a lieu en tous les points de Lebesgue.*

Théorème II. *Si*

1) $\int_{-\infty}^{+\infty}\frac{|f(t)|}{1+|t|}\,dt<+\infty$,

2) $|tk(t)|\leqslant M<+\infty$,

3) *il existe une fonction* $k_1(z)$ *qui satisfait aux conditions* a), b), c) *du théorème* I,
alors la relation (*) *a lieu en chaque point de Lebesgue.*

Remarque. Posons (ce qui ne restreint pas la généralité) $x=0$ et $k(t)=0$ pour $t<0$.

De plus, nous pouvons supposer que $f(0)=0$. En effet, soit

$$\varphi(t)=\begin{cases} f(0) & \text{dans l'intervalle } (0,1)\\ 0 & \text{partout ailleurs}\end{cases}$$

nous avons alors,

$$\left|n\int_0^\infty\varphi(t)\,k(nt)\,dt-\varphi(0)\int_0^\infty k(t)\,dt\right|=\left|\int_0^\infty\left\{\varphi\left(\frac{t}{n}\right)-\varphi(0)\right\}k(t)\,dt\right|\leqslant$$

$$\leqslant|\varphi(0)|\int_n^\infty|k(t)|\,dt$$

et il suffit de prouver le théorème pour la différence $f(t)-\varphi(t)$.

Donc, nous allons démontrer la relation suivante

$$\lim_{n\to\infty}n\int_0^\infty f(t)\,k(nt)\,dt=0$$

à condition que

$$\lim_{h\to 0}\frac{1}{h}\int_0^h|f(t)|\,dt=0.$$

Démonstration du théorème I. A tout nombre positif ε correspond un nombre positif δ tel qu'on a pour $h \leqslant \delta$:

$$\frac{1}{h}\int_0^h |f(t)|\,dt < \varepsilon.$$

Pour ce nombre δ nous avons:

$$n\int_0^\delta |f(t)\ k(nt)|\,dt \leqslant \int_0^\delta |f(t)|\,nk_1(nt)\,dt$$

et (en vertu du lemme de Natanson)

$$\int_0^\delta |f(t)|\,nk_1(nt)\,dt \leqslant 4\varepsilon \int_0^\infty k_1(t)\,dt.$$

D'autre part

$$n\int_\delta^\infty |f(t)|\,|k(nt)|\,dt \leqslant \Big(\int_\delta^\infty \frac{|f(t)|^p}{t}\,dt\Big)^{\frac{1}{p}} \cdot \Big(\int_\delta^\infty n^q t^{q-1} |k^q(nt)|\,dt\Big)^{\frac{1}{q}}.$$

Le premier facteur de ce produit est un nombre fini et pour le second nous avons

$$\Big(\int_\delta^\infty n^q t^{q-1} |\,k^q(nt)|\,dt\Big)^{\frac{1}{q}} = \Big(\int_{n\delta}^\infty |\,t^{q-1} k^q(t)|\,dt\Big)^{\frac{1}{q}}.$$

En vertu de la condition 2) cette dernière intégrale tend vers zéro, quand $n \to \infty$, c. q. f. d.

Démonstration du théorème II. Nous avons

$$n\int_0^\infty f(t)\,k(nt)\,dt = n\int_0^a f(t)\,k(nt)\,dt + n\int_a^b f(t)\,k(nt)\,dt + n\int_b^\infty f(t)\,k(nt)\,dt.$$

Le premier membre de la somme tend vers zéro avec a, ce qu'on peut démontrer comme auparavant.

D'autre part,

$$n\int_b^\infty |f(t)|\,|k(nt)|\,dt \leqslant \int_b^\infty \Big|\frac{f(t)}{t}\,ntk(nt)\Big|\,dt \leqslant M\int_b^\infty \frac{|f(t)|}{t}\,dt$$

et par conséquent le troisième membre doit tendre vers 0 quand b croît indéfiniment.

Il nout reste de montrer que pour deux nombres arbitraires a et b $(0 < a < b < \infty)$ on a l'égalité

$$\lim_{n\to\infty} n\int_a^b f(t)\,k(nt)\,dt = 0.$$

Mais cette affirmation résulte immédiatemont du lemme cité de Bochner et Izumi, si l'on pose

$$g(t) = \frac{f(t)}{t} \text{ et } H(t) = tk(t).$$

Remarque 1. Supposons que $f(t)$ est une fonction bornée, $|f(t)| \leqslant M$ et $k(t)$ satisfait à la condition 3) du théorème I; alors la relation (*) a lieu en tous les points de Lebesgue. En effet

$$\left| n \int_0^\infty f(t)\, k(nt)\, dt \right| \leqslant n \int_0^\delta |f(t)|\, k_1(nt)\, dt + M \int_{n\delta}^\infty k_1(t)\, dt.$$

Le premier membre de la somme tend vers zéro avec δ ce que l'on établit comme dans le théorème I et le second tend vers zéro quand n croît indéfiniment.

Remarque 2. Le théorème I, le théorème II et la remarque 1 sont applicables pour le noyau de Weierstrass:

$$k(t) = e^{-t^2}.$$

Par conséquent, si la fonction $f(t)$ est bornée ou satisfait aux conditions du théorème I ou bien du théorème II, le passage à la limite

$$\lim_{n\to\infty} \frac{n}{\sqrt{\pi}} \int_{-\infty}^{+\infty} f(t)\, e^{-n^2 (t-x)^2}\, dt = f(x)$$

est permis en tous points de Lebesgue (c'est-à-dire presque partout).

Université de Leningrad.

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[1] The Tôhoku Mathematical Journ., **42**, part II, p. 191 — 194. [2] Trans. of the Leningrad Industrial Institute, № 4, 39 (1937).

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MATHÉMATIQUES

SUR UNE CLASSE DE TRANSFORMATIONS QUASI-CONFORMES ET SUR LES SILLAGES GAZEUX

Par M. LAVRENTIEFF

(Présenté par I. M. Vinogradow, de l'Académie, le 9.VI.1938)

I. Définitions. Soit $q(t)$ une fonction positive possédant des dérivées des deux premiers ordres et soit $|q''(t)| \leqslant M$. Nous dirons que la transformation

$$w = f(z) = u(x, y) + iv(x, y)$$

d'un certain domaine D du plan $z = x + iy$ appartient à la classe A_q, si les conditions suivantes sont vérifiées en chaque point (x_0, y_0) du domaine D.

1. Les fonctions u et v possèdent en chaque point du domaine D des dérivées partielles continues par rapport à x et y et le déterminant fonctionnel $\frac{D(u, v)}{D(x, y)}$ est positif.

2. Dans la transformation linéaire

$$u = \frac{\partial u(x_0, y_0)}{\partial x_0} x + \frac{\partial u(x_0, y_0)}{\partial y_0} y,$$
$$v = \frac{\partial v(x_0, y_0)}{\partial x_0} x + \frac{\partial v(x_0, y_0)}{\partial y_0} y$$

un cercle K du plan z se transforme en une ellipse E dont les axes sont parallèles aux axes des coordonnées.

3. En prenant le rayon du cercle K égal à 1 et en désignant par V et b les demi-axes de l'ellipse E parallèles respectivement aux axes u et v, on a

$$V = bq(V).$$

Il suit immédiatement de la définition donnée que si $q(t) \equiv 1$, les fonctions de la classe A_q seront analytiques. Il est d'ailleurs facile à voir que si

$$q(t) = q_0(t) = \left(1 - \frac{t^2}{2\alpha}\right)^{-\beta}$$

où α et β sont des constantes positives, les fonctions u et v vérifient les équations de la dynamique des gaz pour les courants stationnaires; les problèmes sur la construction des courants stationnaires sont équivalents aux problèmes sur la construction des transformations, de la classe A_{q_0},

du domaine du courant sur des domaines de type spécial. $V = V(z)$ déterminera la valeur de la vitesse du courant au point z.

II. Propriétés fondamentales des transformations de la classe A_q. Dans la suite on ajoutera aux conditions précédemment énoncées les conditions suivantes concernant la fonction $q(t)$: 1) $q(t)$ est bornée supérieurement et inférieurement par des constantes positives; 2) quel que soit t positif, on a

$$q(t) - tq'(t) > k > 0, \quad k = \text{const.}$$

Remarquons que pour les transformations qui déterminent le courant d'un gaz ces conditions sont vérifiées pour toutes les vitesses qui ne surpassent pas la vitesse du son.

Théorème 1. *Soient* $y = y_1(x)$, $y = y(x)$ *et* $y = \bar{y}(x)$, $|x| < \infty$ *trois courbes données,*

$$y_1(x) < \bar{y}(x) \leqslant y(x),$$

chacune des fonctions $y, y_1, \bar{y}$ *étant uniforme et possédant une dérivée seconde bornée. Soient* $w = f(z)$ *et* $w = \bar{f}(z)$ *les transformations de classe* A_q *des domaines* $y_1(x) < y < y(x)$ *et* $y_1(x) < y < \bar{y}(x)$ *respectivement sur la bande* $0 < v < h$ *en supposant que les points frontières à l'infini sont correspondants. Dans ces conditions on a en tous les points de la courbe* $y_1(x)$:

$$\frac{df(z)}{ds} \leqslant \frac{d\bar{f}(z)}{ds};$$

si, d'ailleurs, on a $y(x_0) = \bar{y}(x_0)$, *alors au point* $[x_0, y(x_0)]$ *on aura*

$$\frac{df(z)}{d\sigma} \geqslant \frac{d\bar{f}(z)}{d\sigma},$$

où ds *et* $d\sigma$ *sont respectivement les différentielles des arcs des courbes* $y_1(x)$ *et* $y(x)$. *Les signes d'égalité n'ont lieu que dans le cas où* $y(x)$ *coïncide avec* $\bar{y}(x)$.

Théorème 2. *Supposons que la courbe* $y = y(x)$, $y(x) > 0$, *vérifie les conditions du théorème 1 et qu'au point* x_0 *la dérivée* $y'(x)$ *atteint son maximum* (minimum) *tandis qu'au voisinage de ce point* $y''(x)$ *vérifie la condition de Hölder. Dans ces conditions, en désignant par* $w = f(z)$, $f(-\infty) = -\infty$, $f(\infty) = \infty$ *la transformation de classe* A_q *du domaine* $D: 0 < y < y(x)$ *sur la bande* $0 < v < h$, *on a au point* $[x_0, y(x_0)]$ *l'inégalité*

$$\frac{d^2f(z)}{ds^2} < 0 \qquad \left(\frac{d^2f(z)}{ds^2} > 0\right).$$

Théorème 3. *En conservant les notations du théorème 2, si la courbe* $y(x)$ *contient un arc* γ *de la circonférence d'un cercle K situé hors du domaine D* (dans le domaine D), *la fonction* $V = \frac{df(z)}{ds}$ *ne peut atteindre son minimum* (maximum) *sur l'arc* γ.

III. Théorèmes d'existence. Les propositions précédemment énoncées peuvent être démontrées par une méthode purement géométrique ainsi que le théorème fondamental d'existence suivant.

Théorème 4. *Soient* $y = y_1(x)$ *et* $y = y(x)$ *deux courbes données vérifiant les équations du théorème 1 et* $q(t)$ *une fonction bornée supérieurement et inférieurement et vérifiant 2). Dans ces conditions il existe une transformation* $w = f(z)$, $f(-\infty) = -\infty$, $f(\infty) = \infty$, *de classe* A_q *qui fait correspondre au domaine* $y_1(x) < y < y(x)$ *la bande* $0 < v < h$. *Cette trans-*

formation est unique, abstraction faite d'une translation de la bande $0 < v < h$, *et elle dépend d'une manière continue du paramètre* h.

En s'appuyant sur les propositions qui viennent d'être énoncées, on peut démontrer l'existence de la solution et en établir certaines propriétés qui s'appliquent dans les problèmes de la théorie des sillages. Désignons par

$$w = f(z, \gamma, q, h),\ f(-\infty, \gamma, q, h) = -\infty,\ f(\infty, \gamma, q, h) = \infty$$

la transformation de la classe A_q du domaine borné par les lignes γ_1 et γ sur la bande $0 < v < h$.

Théorème 5. *Soit* γ_1 *une courbe située dans le demi-plan inférieur et définie par une fonction uniforme de* x : $y = F_1(x)$, $|F_1'(x)| < C = \text{const}$, $|x| < \infty$. *Soit, d'ailleurs,* Γ_1 (*un arc*): $y = \varphi(x)$, *où* $\varphi(x)$ *est uniforme, possède des dérivées des deux premiers ordres sur le segment* $(0, x_1)$ *et d'ailleurs* $\varphi(x) > F_1(x)$. *Dans ces conditions il existe une et une seule courbe* $\Gamma_2 : y = \psi(x)$, $\psi(x_1) = \varphi(x_1)$, $\psi(x) \leqslant 0$, *définie pour* $x \geqslant x_1$ *et telle qu'en chacun de ses points à ordonnée négative on a*

$$\frac{df(z, \gamma, q, h)}{ds} = c = \text{const},$$

où γ *est la courbe formée de la partie négative de l'axe* x, *de l'arc* Γ_1 *et de la courbe* Γ_2, *tandis que* ds *est la différentielle de l'arc* γ. *La fonction* $f(z, \gamma, q, h)$ *ainsi obtenue est une fonction continue de* h.

Indiquons une conséquence aérodynamique du dernier théorème. Supposons que pour $x \to \pm\infty$ la fonction F_1 tend vers les limites non nulles et étudions le problème sur l'existence dans la bande $|y| < -F_1(x)$ d'un courant gazeux dont le potentiel $\varphi(x, y, V)$ est tel que l'on a: 1) $\varphi(x, y, V_\infty) = +\varphi(x_1 - y, V_\infty)$; 2) le long des arcs de $\pm\varphi(x)$ et des courbes $y = \pm\psi(x, V_\infty)$, $\psi \leqslant 0$, on a $\frac{d\varphi}{dn} = 0$, où dn est l'élément de la normale à une ligne $\pm\varphi$, $\pm\psi$; 3) le long de la ligne $y = \pm\psi(x, V_\infty)$ pour $\psi(x, V_\infty) < 0$ on a $|\text{grad}\,\varphi| = \text{const}$.

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PHYSICS

DETERMINATION OF RYDBERG CONSTANTS FOR HYDROGEN AND DEUTERIUM

By VS. ČERNJAIEV

(Communicated by S. I. Wawilow, Member of the Academy, 10.VI.1938)

There were recently made some calculations of different physical constants, e. g. $\frac{e}{m_0}$, fine structure constant α and others from the spectra of hydrogen and deuterium (1). The exact value of the Rydberg constant for deuterium is, however, not yet to be found in literature. The rough determination of R_D (2) which was made without using of fine line structure cannot be taken into account. The value of R_D quoted in White's book (3) had probably been simply calculated from the data for the masses of proton and deuteron available at that time. The object of the present work was to study the fine structure of hydrogen and deuterium lines in order to determine the value of R_D and R_H, and, moreover, to make new determinations of some other constants.

A discharge tube of an inner diameter of 5 mm, immersed in liquid air, was filled with helium or with neon under pressure of about 0.1 mm. Traces of hydrogen and deuterium in about equal amounts were present in the discharge (4). The discharge was obtained by means either of a 2000 V transformer, or by a direct 3000 V current. The current in the tube amounted to 150—200 mA. The spectra were taken by means of a great diffraction grating with radius of curvature 640 cm, having 180 000 rulings, at 30 000 lines per inch, which had been ruled by Wood and Ferry.

The H_α and D_α lines were taken in the first order (since the red part of the second order lay beyond the slit and the grating at that angle was partly screened by a bulky box in which it had been placed to ensure the best protection against temperature variations). The H_β, D_β and H_γ, D_γ lines were photographed in the second order. By means of stepwise filters which were placed right against the plates, marks of intensity were superimposed on the same plates in addition to the lines themselves. Using these marks, the enlarged projections of the microphotometer curves were converted into intensity curves.

No systematic difference was to be observed between the shapes of the lines and between the intensity ratios of the main components neither when the tube was filled with neon or with helium, nor when it was treated by alternating or by direct current. The intensity ratio of the short-wave to the long-wave component was somewhat different for different plates (this probably being due to the influence of pressure which failed to be accurately measured).

The average values of these ratios (from ten plates for H_α and D_α, four plates for H_β, D_β and four for H_γ, D_γ) are given in Table 1.

Table 1

Intensity Ratio of Short-Wave to Long-Wave Doublet Component (I_k/I_l)

Line	I_k/I_l observ.	I_k/I_l theoret.
H_α	0.83	0.80
D_α	0.82	
H_β	0.91	0.91
D_β	0.89	
H_γ	0.96	0.96
D_γ	0.94	

The ratios observed are near to the theoretical ones, though in most of the previous investigations the difference is greater. The current strength in the present work, however, was large enough, and as the current increases, the intensity distribution must approach the theoretical one ([5]). A somewhat lower ratio for D lines has scarcely any real importance, since H lines are wider and the more intense long-wave component can be slightly superimposed upon the short-wave one, somewhat raising the maximum of the latter.

On the microphotograms and on the intensity curves for H_α and D_α the asymmetry of the short-wave component may be easily seen, which is due to the presence of the $2S_{1/2},P_{1/2}—3P_{1/2},S_{1/2}$ component. For the H_β and D_β lines this asymmetry is much smaller, and can scarcely be seen for the H_γ and D_γ lines. The long-wave component is symmetrical.

The wave lengths of the maximum of long-wave components of H_α and D_α were carefully measured by means of neon wave length standards $\lambda\lambda = 6506.528$ Å; 6532.882 Å and 6598.953 Å, which were superimposed on the plate simultaneously with hydrogen lines when the tube was filled with neon and the spectrum of hydrogen did not yet predominate ([4]). The mean values of air wave lengths and of corresponding vacuum wave numbers for the long-wave components of H_α and D_α, as derived from six plates, are given in table 2.

Table 2

	λ air (Å)	ν vac. (cm^{-1})
H_α^l	6562.846±0.002	15 233.091±0.0046
D_α^l	6561.063±0.002	15 237.232±0.0046
	$\Delta\lambda = 1.783 \pm 0.004$	$\Delta\nu = 4.141 \pm 0.0092$

To obtain from these wave numbers of the maxima of the long-wave components the wave numbers of the most intense components ($2P_{^3/_2}—3D_{^3/_2}$), a correction is required. As for our case the intensities of the doublet-components are near to those predicted by theory, one can suppose that the distribution of intensities among the separate components of the fine structure agrees with the theoretical one. If so, the center of gravity of the long-wave group consisting of three components is shifted with respect to the position of the $2P_{^3/_2}—3D_{^3/_2}$ component towards the greater wave lengths by about

0.006 cm^{-1}. But as the width of the lines is finite, the center of gravity of the group of the components does not necessarily coincide with the measured maximum of intensity. Williams and Gibbs [6] had shown that when the width of the components is of the order of breadth which is obtained in a tube immersed in liquid air, the intensity maximum of the long-wave group for H_α and D_α is separated from the position of the $2P_{3/2}$—$3D_{5/2}$ component by a distance of only about 0.003 cm^{-1}. Assuming therefore this correction to be +0.003 cm^{-1}, from the figures of Table 2 we obtain the wave numbers for the $2P_{3/2}$—$3D_{5/2}$ components:

$$H'_\alpha : (15\,233.094 \pm 0.0046)\ cm^{-1}$$
$$D'_\alpha : (15\,237.235 \pm 0.0046)\ cm^{-1}.$$

Using Diracs's equation for the wave numbers of terms

$$\nu_i = -\frac{R}{n^2}\left[1 + \frac{\alpha^2}{n^2}\left(\frac{n}{i+\frac{1}{2}} - \frac{3}{4}\right)\right],$$

and putting $\alpha^2 = 5.297 \cdot 10^{-5}$ [7] and the corresponding quantum numbers, we obtain the wave number of the $2P_{3/2}$—$3D_{5/2}$ component: $\nu = 0.138889553\ R$.

Using then the measured values of ν, we arrive at the values

$$R_H = (109\,677.753 \pm 0.030)\ cm^{-1}$$
$$R_D = (109\,707.567 \pm 0.030)\ cm^{-1}.$$

If we assign to α^2 the value $5.305 \cdot 10^{-5}$ [8], then the difference from the above values reaches only about 0.002 cm^{-1}.

Using then the equations

$$\frac{M_P}{m_0} = \frac{\nu_D}{\nu_D - \nu_H} \cdot \frac{M_D - M_P}{M_D} - 1,$$
$$\frac{e}{m_0} = \frac{M_P}{m_0} \cdot \frac{F}{A_H},$$

where m_0, M_P and M_D are the masses of electron, proton and deuteron respectively, F—the Faraday number, A_H—the atomic weight of hydrogen, and substituting the values of M_D and M_P after Aston [9], the value of F after Birge [8] and the measured values of ν, we obtain the values for the ratio of the mass of the proton to the mass of the electron and for the specific charge of the electron. We can also calculate, from the latter values, the Rydberg constant for the infinitely heavy nucleus, the atomic weight of the electron, its mass and its charge, and the fine structure constant α. The values of Birge [8] for the velocity of light, Planck's constant, and the mass of the proton were made use of. Besides, from the values of R_D, R_H and $\frac{M_P}{m_0}$ the ratio of the mass of deuteron to that of proton was also calculated.

As the error in the value of $\frac{M_P}{m_0}$ is rather large, this results in a considerable error for m_0, which in turn produces a lack of accuracy in the determination of e and α. It is this initial error that is also responsible for a considerable inaccuracy in the determination of R_∞ and $\frac{M_D}{M_P}$. However, all the values calculated (possibly except that of α) agree within the limits of experimental errors with the measurements of others authors [1,8,9,10]. The error in the value of α did not affect the values of R_D and R_H, since the value of α used in their computation was that measured by other authors with greater precision, by means of an interferometer. Besides, the error in R depends almost wholly upon an error of measurements of the absolute

Table 3

Quantity	Value
Rydberg constant for hydrogen, R_H	$(109\,677.75_3 \pm 0.030)$ cm^{-1}
Rydberg constant for deuteron, R_D	$(109\,707.56_7 \pm 0.030)$ cm^{-1}
Rydberg constant for the infinitely heavy nucleus, R_∞	$(109\,737.4_{58} \pm 0.16)$ cm^{-1}
Proton to electron mass ratio, $\frac{M_P}{m_e}$	$1\,837 \pm 4$
Specific charge of the electron, $\frac{e}{m_0}$	$(1.758 \pm 0.004) \cdot 10^7$ $\frac{\text{E.M.U.}}{\text{g}}$
Atomic weight of the electron, A_{el}	$(5.488 \pm 0.010) \cdot 10^{-4}$
Mass of the electron, m_0	$(9.11_8 \pm 0.030) \cdot 10^{-28}$ g
Charge of the electron, e	$(1.603 \pm 0.009) \cdot 10^{-20}$ E.M.U. or $(4.80_6 \pm 0.027) \cdot 10^{-10}$ CGSE
Fine structure constant, α	$(7.39 \pm 0.10) \cdot 10^{-3}$
Deuteron to proton mass ratio, $\frac{M_D}{M_P}$	1.998 ± 0.018

values of wave numbers. The value of $\frac{M_D}{M_P}$ as measured by means of the mass-spectrograph ([9]) is equal to $1.9985 + 0.00015$. Our value coincides with the latter within the limits of error, but natural enough such an indirect method of measurement should involve a much greater lack of accuracy than that found in Aston's experiments.

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PHYSICS

ON THE FLUORESCENCE OF SOLUTIONS OF SALTS OF CERIUM

By A. N. FILIPPOV, J. LARIONOV and A. SEIDEL

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As had been stated before ([1], [2]), aqueous solutions of cerous salts, when excited by the light of an iron spark, exhibit a bright violet fluorescence. We have investigated this phenomenon, using a procedure described elsewhere ([3],[4]). Cerous nitrate tested beforehand spectroscopically was used for the preparation of the solutions. On the spectrograms of this preparation taken on a 6.4 meter concave diffraction grating of the State Optical Institute ([5]) no ultimate lines of any rare earth except those of cerium could be detected.

Solutions of cerous sulphate and chloride were investigated. The fluorescence spectrum was found in both cases to be identical and to consist of one characteristic broad band lying between 313 and 407 mμ.

The same band is present in the fluorescence spectrum of the solutions of ceric salts; however, its intensity is much smaller as compared with solutions of corresponding concentrations of cerous salts. A special investigation has shown that the fluorescence of the solutions of ceric salts is caused by the presence of cerous ions due to the action of the ultra-violet radiation of the spark. A similar photochemical action of the ultra-violet radiation on the solution of perchlorate of cerium was recently discovered by Weiss and Porret ([6]) who have given a provisory interpretation of this phenomenon.

It would be of interest to draw a scheme of transitions accounting for the fluorescence described. For a number of rare earths such schemes are available ([1],[7]). However, unfortunately, up to the present it was found impossible to work out such a scheme for cerium. An attempt recently made by Gobrecht ([8]) is to be considered a failure. Gobrecht asserts that the fluorescence of the aqueous solutions of cerous sulphate is very faint and lies in the ultra-violet region of the spectrum, so that it can be detected only photographically. Moreover, in contradiction with the data of Haitinger ([9]) who has observed the fluorescence of solid solutions of cerium in borax, Gobrecht affirms that borax activized by cerium does not fluoresce. As we have already shown, the first assertion fully disagrees with experimental data. The violet fluorescence of the aqueous solutions of cerium is very bright and can be easily observed visually; it can be used with success for purposes of semi-quantitatve analytical detection of cerium ([2]). Special experiments have shown that

Gobrecht's second assertion is not consistent with reality either. The fluorescence of borax activized by cerium is very intense; its colour is blue, which perfectly agrees with Haitinger's data. The spectrum of fluorescence of borax activized by cerium consists of one band, broader than the fluorescence band of aqueous solutions of cerium. At —180° C this band does not grow narrower and shows no signs of structure. It is interesting to note that the fluorescence of borax is so bright that its spectrum can be taken on a medium model of Hilger's spectrograph with a slit 0.05 mm wide in two minutes.

Gobrecht's failure to observe these phenomena may be explained by the unadequate experimental method he used. First of all it is to be noted, that the existence of strong absorption in cerium causes a rapid drop of the intensity of fluorescence along the exciting beam and a sharp shortening of the length of the fluorescence pencil. In order to obtain large intensities, very small concentrations of Ce of an order of hundredths per cent ought to be taken. Gobrecht has worked on the contrary with concentrated solutions. Moreover, Gobrecht's choice of the source of the exciting light was wrong too. Gobrecht has used the light of an under-water spark between tungsten electrodes, filtered through a Cl—Br filter, and a carbon arc. Excitation by a spark or an arc between iron electrodes, as used by us and Haitinger, gives incomparably better results both for aqueous solutions and solutions in borax. Owing to these two methodical errors, Gobrecht could evidently observe only the maximum of the fluorescence band in aqueous solutions of cerium and has totally overlooked the fluorescence of the activized borax. The error in the measurement of the real long-wave limit of the fluorescence band that has ensued thereof has enabled Gobrecht to suggest a scheme of the process of fluorescence of cerium that consists in the following: under the action of the exciting radiation the ion CeIV is raised from the normal state $^2F_{5/2}$ to the excited state ^2D, and returns therefrom to the state $^2F_{7/2}$, emitting a quantum of light with a frequency corresponding to the fluorescence band. It is easy to show, however, that the energy balance of this scheme does not agree with experimental data. If the scheme proposed by Gobrecht be true, the long-wave limit of the fluorescence spectrum ought to be displaced as compared with the long-wave limit of absorption on the value of the splitting of the term $^2F_{5/2}$, $_{7/2}$ towards the long waves. This latter value was determined by Lang who has obtained 2150 cm^{-1} for the difference between the wave-numbers of the terms $^2F_{5/2}$ and $^2F_{7/2}$ ([10],[11]). It is to be noted that although Lang has worked with cerium vapour, the spiltting of the normal term of a rare earth ion belonging to the $4f$ shell cannot change very much with the change of the aggregation.

A value of the same order (1500 cm^{-1}) was obtained by Brunetti and Ollano ([12]) who have investigated the Raman effect in solutions of $CeCl_3$ and $Ce(NO_3)_3$ and the temperature dependence of the paramagnetism of cerous salts solutions. It is to be noted that both these papers have been overlooked by Gobrecht.

The splitting of the term $^2F_{5/2}$, $_{7/2}$ can be evaluated using Sommerfeld's formula and is found by Gobrecht to make up 3500 cm^{-1}. It is to be noted, however, that Gobrecht has made use of a rather small value of the constant of screening: $\sigma=32$. A more probable value of $\sigma=34$ would lead to the value of 2540 cm^{-1} which is in better agreement with Lang's data. On the other hand, our measurements show that the difference between the long-wave limit of the absorption (325 mμ) and that of the fluorescence spectrum (407 mμ) is equal to 6200 cm^{-1}. Such a divergence (4000 cm^{-1}) can hardly be attributed to the inaccuracy of the measurements of the limits of the bands.

We believe that the scheme of the process of the emission of the ion CeIV is more complicated than that suggested by Gobrecht. It seems that in con-

trast with such rare earths as Tb, Eu, Gd, Sm and Dy in which both emission and absorption can be attributed to transitions $4f$—$4f$ ([1]), the ion CeIV cannot be considered as an isolated system. In the case of cerium, the surrounding medium does influence not only the fluorescence capacity and the finer details of the spectrum. This type of fluorescence is probably nearer to the fluorescence of complex molecules of organic dyestuffs for which such a displacement of the spectrum of emission as compared with that of absorption is observed in reality. A decisive answer requires, however, further investigations. This point of view is confirmed also by the considerable influence that is exerted by the solvent (water and borax) on the emission and absorption spectra of cerium, and the absence of an afterglow in cerium solutions.

It is interesting to note that for the first time the fluorescence of cerous solutions was discovered visually as early as in 1880 by Soret ([13]). In 1908 the spectra of the solutions of the salts of unknown degree of purity were taken by Stark and Streubing ([14]). These investigators have also used a condensed spark between metallic electrodes as a source of excitation. Their work was, however, also overlooked by Gobrecht.

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PHYSICS

THE PROBLEM OF ELECTRON INTERACTION IN METALS

By L. E. GUREVICH

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The subject of this work is the interaction of electrons in metals, and the limits of the theory of the non-interacting electrons.

§ 1. The Quasi-Impulse of the System. Owing to the translational symmetry (periodicity) of the lattice the wave function of the system of the electrons has the following property:

$$\psi(\vec{r}_1+\vec{a},\ \vec{r}_2+\vec{a},\ \ldots)=e^{iN\vec{F}\vec{a}}\psi(\vec{r}_1\vec{r}_2\ldots),$$

where $\vec{a}$ is an arbitrary lattice vector. Multiplying by $e^{-i\vec{F}\Sigma(\vec{r}_i+\vec{a})}$ we obtain:

$$e^{-i\vec{F}\Sigma(\vec{r}_i+\vec{a})}\psi(\vec{r}_1+\vec{a},\ \ldots)=e^{-i\vec{F}\Sigma\vec{r}_i}\psi(\vec{r}_1,\ \ldots)=u_F(\vec{r}_1,\ \ldots). \qquad (1)$$

The function u_F does not change when the co-ordinates of all the electrons are shifted by the same lattice vector; hence this function depends periodically (with the lattice period) on the co-ordinates of the single electrons, and besides depends arbitrarily on their respective distances. Therefore, it may be written in the form:

$$u_F(\vec{r}_1,\ \ldots)=\sum_{b_1,\,b_2\ldots}A_{F,b_1b_2\ldots}(\vec{r}_{12}\ldots)\,e^{i\Sigma\vec{b}_\alpha\vec{r}_\alpha},$$

where $\frac{1}{2\pi}\vec{b}_\alpha$ is a vector in the reciprocal lattice. The coefficients A depend on their arguments in an unknown way. In the case of the non-interacting electrons they have the form

$$\sum_g B_{g_{12}\ldots}\,e^{i\Sigma\vec{g}_{\alpha\beta}\vec{r}_{\alpha\beta}},$$

where B are constants. In the case of interacting electrons it is always possible to separate the periodic part of the coefficients A, so that B be functions rapidly decreasing with distance, probably of exponential character. Then

$$u_F=\sum_{b,\,g}B_{b,\,g}\,e^{i\Sigma(\vec{g}_\alpha+\vec{b}_\alpha)\vec{r}_\alpha}$$

where

$$\sum \vec{g}_a = 0. \tag{2}$$

Substituting this expression into (1), we have

$$\psi_F = \sum_{\varphi_1 \varphi_2 \ldots} B_{\varphi_1 \varphi_2 \ldots} e^{i \vec{\Sigma} \vec{\varphi}_a \vec{r}_a} \tag{3}$$

where

$$\vec{\varphi}_a = \vec{F} + \vec{g}_a + \vec{b}_a = \vec{f}_a + \vec{b}_a. \tag{4}$$

The condition

$$-\frac{\pi}{d} \leqslant F \leqslant \frac{\pi}{d} \tag{5}$$

defines univaluedly the resulting quasi-impulse $\vec{F}$. But generally the quasi-impulse $\vec{F}$ is not single-valued; an arbitrary vector $\vec{b}$ of the reciprocal lattice may be added to it; therefore, every physical quantity (e. g. the energy) must depend on it periodically with the period $\vec{b}$. As the energy is an even function of the quasi-impulse, it may be written in the form of a Fourier series:

$$E_F = \sum_a C_a \cos \vec{F} \vec{a}. \tag{6}$$

For a single electron the Bloch formula is a special case of (6). It is usually obtained with the help of the perturbation theory; but such a derivation is not convincing, since the «perturbation» is (or may be) very great.

In our case (6) is not so important, as usually, for the energy is an almost continuous function not only of the resulting quasi-impulse, but also of the other quantum numbers, characterizing the relative motion of the electrons (the «hyperbolic orbits»); the quasi-impulse $\vec{F}$ has little physical meaning, as owing to the conditions (5) it is not additive. The rapid drop of the coefficients B with the distances corresponds to the screening of electrons by ions. Choosing a definite form of the functions B, we can define their parameters by a variational method. This method will yield more accurate results than that of the «self-consistent field» or that of Wiegner and Seitz.

§ 2. The Limits of the Validity of the Single Electron Theory. The kinetic properties of the conductors and a number of equilibrium properties do not depend on all the conducting electrons, but only on those of them, that are located near the maximum zero energy, in the diffuse part of the Fermi distribution curve. But these electrons are few in number: they represent only a fraction $\frac{kT}{\varepsilon_0}$ of all the electrons of the conducting band. Therefore the ratio of their mean distance to the lattice constant is of the order $\left(\frac{\varepsilon_0}{kT}\right)^{1/3}$, hence they are mutually screened by ions and their interaction is small. This holds not only in the case of equilibrium, but also for the kinetic phenomena. Indeed, if all the electrons were taking part in the conductivity, the effective cross-section for their collisions would be limited only by the screening due to the properties of the Coulomb forces; it would be of the order of the atomic cross-section $s \approx 10^{-16}$ cm^2. But actually this

effective cross-section, if averaged over all the electrons, decreases in the ratio $\left(\frac{kT}{\varepsilon_0}\right)^2$, as the colliding electrons must be located in the region near the maximum zero energy before the collision as well as after it. Hence the time of relaxation

$$\tau \approx \frac{1}{n s v_0} \left(\frac{\varepsilon_0}{kT}\right)^2. \tag{7}$$

The very same result has been obtained by Pomeranchuk and by Baber.

As the diffuse part of the Fermi distribution curve is very narrow ($kT \ll \varepsilon_0$), the energy of the electron may be expanded into the following series:

$$\varepsilon(f, \vartheta, \varphi) = \varepsilon_0(\vartheta, \varphi) + \left(\frac{\partial \varepsilon}{\partial f}\right)_0 \Delta f + \frac{1}{2}\left(\frac{\partial^2 \varepsilon}{\partial f^2}\right)_0 \Delta f^2, \tag{8}$$

where $\Delta f = f - f_0$, and f_0 is the absolute value of the quasi-impulse, having the same direction ϑ, φ, but corresponding to the zero energy $\varepsilon_0(\vartheta, \varphi)$ in this direction.

§ 3. Mathematical Treatment. The wave function of the interacting electrons may be represented as a series of wave functions $\psi_f = \frac{1}{\sqrt{V}} e^{i\vec{f}\vec{r}} u_f(\vec{r})$ of non-interacting electrons. This representation will be more convenient for our purposes, than the previous one (§ 1). In this expression which may be also obtained by the method of § 1, u_f is periodic with the period of the lattice, hence $u_f = \sum_b D_{f,b} e^{i\vec{b}\vec{r}}$, so that $\psi_f = \frac{1}{\sqrt{V}} \sum_b D_{f+b} e^{i(\vec{f}+\vec{b})\vec{r}}$. Taking $\vec{f} + \vec{b} = \vec{\varphi}$, we may write the wave function of the interacting electrons in the form

$$\psi = \frac{1}{V^{N/2}} \sum_{\varphi_1 \varphi_2 \dots} D_{\varphi_1 \varphi_2 \dots} e^{i \sum_\alpha \vec{\varphi}_\alpha \vec{r}_\alpha}. \tag{9}$$

A comparison with (2) and (4) gives:

$$\vec{F} = \frac{1}{N} \sum_\alpha \vec{f}_\alpha, \tag{10}$$

so that the summation in (9) is limited by the condition (10). The normalization condition is:

$$\sum_{\varphi_1 \varphi_2 \dots} |D_{\varphi_1 \varphi_2 \dots}|^2 = 1. \tag{11}$$

Owing to the Pauli principle the coefficients D do not contain more than twice every value φ_α; they are antisymmetric with respect to the transpositions of two different unequal quantities φ and φ'.

In the case of the Coulomb interactions of the electrons and of the electrons with the ions the Schrödinger equation has the form:

$$\left\{-\frac{\hbar^2}{2m} \sum_\alpha \Delta_\alpha - e^2 \sum_{\alpha, a} \frac{1}{|\vec{r}_\alpha - \vec{a}|} + \frac{e^2}{2} \sum_{\alpha, \beta} \frac{1}{r_{\alpha\beta}}\right\} \psi = E\psi.$$

Let us take ψ in the form (9), substitute φ' for φ, multiply by $e^{-i\sum_a \vec{\varphi}_a \vec{r}}$ and integrate over the volume of the crystal. We obtain:

$$D_\varphi E = \left(\sum_a \frac{\hbar^2 \varphi_a^2}{2m}\right) D_\varphi - \frac{e^2}{V} \sum_{\alpha,\alpha,\varphi'_\alpha} D_{\varphi'_\alpha} \int e^{i(\varphi'_\alpha - \varphi_\alpha) r_\alpha} \frac{d r_\alpha}{|r_\alpha - a|} +$$

$$+ \frac{e^2}{2V^2} \sum_{\alpha\beta\varphi'_\alpha\varphi'_\beta} D_{\varphi'_\alpha \varphi'_\beta} \int e^{i[(\varphi'_\alpha - \varphi_\alpha) r_\alpha + (\varphi'_\beta - \varphi_\beta) r_\beta]} \frac{dr_\alpha dr_\beta}{r_{\alpha\beta}}.$$

$D_{\varphi'_\alpha}$ is here the coefficient which differs from $D_\varphi = D_{\varphi_1 \varphi_2} \ldots$ only by the value of one argument φ'_α, and $D_{\varphi'_\alpha \varphi'_\beta}$ differs from it by the values of two arguments φ'_α and φ'_β. We introduce in the first integral the variable $\vec{r}_\alpha - \vec{a} = \vec{r}$ and take into account that $\sum_a e^{i(\varphi'_\alpha - \varphi_\alpha) a} = N$, if $\vec{\varphi}'_\alpha - \vec{\varphi}_\alpha = b$ and $= 0$ in other cases; then we obtain $N \sum_{\alpha, b} D_{\varphi_\alpha b} + \int e^{ibr} \frac{dr}{r}$. It is necessary to multiply the integrand by an «extinction factor» $e^{-\gamma|r|}$; integrating and taking $\gamma = 0$, we obtain for the second term of our equation $-\frac{4\pi e^2 N}{V} \sum_{\alpha, b} \frac{D_{\varphi_\alpha + b}}{b^2}$. In the third term the integration over the co-ordinates of the centre ol mass of the particles α and β gives $V\delta(\varphi'_\alpha + \varphi'_\beta - \varphi_\alpha - \varphi_\beta)$; introducing $e^{-\gamma|r|}$ and taking $\gamma = 0$, after the integration over the relative co-ordinates we obtain the result

$$\frac{2\pi e^2}{V} \sum_{\alpha,\beta,\varphi'_\alpha} \frac{D_{\varphi'_\alpha;\, \varphi_\beta + \varphi_\alpha - \varphi'_\alpha}}{(\varphi_\alpha - \varphi'_\alpha)^3}.$$

Hence

$$D_\varphi E = D_\varphi \sum_\alpha \frac{\hbar^2 \varphi_\alpha^2}{2m} + 4\pi e^2 n \sum_{\alpha, b} \frac{D_{\varphi_\alpha + b}}{b^2} + \frac{2\pi e^2}{V} \sum_{\alpha,\beta,\varphi'_\alpha} \frac{D_{\varphi'_\alpha;\, \varphi_\beta + \varphi_\alpha - \varphi'_\alpha}}{(\varphi_\alpha - \varphi'_\alpha)^2}. \qquad (12)$$

Multiplying (12) by D_φ^* and summing over all φ, we find in virtue of (11):

$$E_F = \sum_{\alpha, \varphi} \frac{\hbar^2 \varphi_\alpha^2}{2m} |D_\varphi|^2 - 4\pi e^2 n \sum_{\alpha, b, \varphi} \frac{D_\varphi^* D_{\varphi_\alpha + b}}{b^2} + \frac{2\pi e^2}{V} \sum_{\alpha,\beta,\varphi,\varphi'_\alpha} \frac{D_\varphi^* D_{\varphi'_\alpha;\, \varphi_\beta + \varphi_\alpha - \varphi'_\alpha}}{(\varphi_\alpha - \varphi'_\alpha)^2}. \qquad (13)$$

(12) and (13) converge, as the terms corresponding to $\vec{b} = 0$ and $\vec{\varphi}_\alpha = \vec{\varphi}'_\alpha$ together with the Coulomb interaction of the ions compensate themselves. This fact as well as the dimension considerations show that all the three terms in (13) are of the same order of magnitude; the first is of the order $\sim \frac{\hbar^2}{md^2} N$ and the second and the third are of the order $\sim e^2 n N d^2$. But both expressions are of the same order of magnitude, as their relation is $\frac{\hbar^2}{me^2 d} \cdot \frac{N}{nd^3} \approx 1$.

Let us calculate the gradient of the energy with respect to the quasi-impulse $\vec{F}$:

$$\nabla_F E_F = \sum \frac{\hbar^2 \varphi_\alpha}{m} |D_\varphi|^2 + \sum \nabla_F D_\varphi^* \left\{ \sum \frac{\hbar^2 \varphi_\alpha^2}{2m} D_\varphi - 4\pi e^2 n \sum \frac{D_{\varphi_\alpha + b}}{b^2} + \right.$$

$$\left. + \frac{2\pi e^2}{V} \sum \frac{D_{\varphi'_\alpha;\, \varphi_\beta + \varphi_\alpha - \varphi'_\alpha}}{(\varphi_\alpha - \varphi'_\alpha)^2} \right\} + \sum \nabla_F D_\varphi \left\{ \sum \frac{\hbar^2 \varphi_\alpha^2}{2m} D_\varphi^* - 4\pi e^2 n \sum \frac{D^*_{\varphi_\alpha - b}}{b^2} + \right.$$

$$\left. + \frac{2\pi e^2}{V} \sum \frac{D^*_{\varphi'_\alpha;\, \varphi_\beta + \varphi_\alpha - \varphi'_\alpha}}{(\varphi_\alpha - \varphi'_\alpha)^2} \right\} = \sum \frac{\hbar^2 \varphi_\alpha}{m} |D_\varphi|^2 + E_F \nabla_F \sum D_\varphi D_\varphi^* ,$$

as the second bracket is equal to $E_F D_\varphi^*$ in virtue of the equation for the function ψ^* analogous to (12). Hence according to (11)

$$\frac{1}{\hbar} \nabla_F E_F = \dot{\vec{p}}_F = m \sum \dot{\vec{v}}_F = \frac{mV}{e} \dot{\vec{j}}_F . \qquad (14)$$

In particular this relation leads to the Bloch suggestion that the minimum energy level or an unlimited lattice corresponds to the absence of the electron current. This conclusion is valid also in the case of an external magnetic field or even for the magnetically interacting electrons. Hence the spontaneous currents, if they exist, are surface currents. The increase of these currents increases the «volume» energy (13), which compensates the decrease of the surface energy. The theory of the superconductivity may be based on this idea.

§ 4. The Theory of the Non-Interacting Electrons as a First Approximation for Small Thermal Excitations. Let us suppose that a certain combination of the coefficients $D_{\varphi_1 \varphi_2} \ldots$ corresponds to the minimum energy E_0. Then a small excitation of the electrons changes appreciably the dependence of the coefficients $D_{\varphi_1 \varphi_2} \ldots$ only on a small number of the arguments. (However, the change of each coefficient $D_{\varphi_1 \varphi_2} \ldots$ is not small, these coefficients satisfying the orthogonality condition $\sum D_\varphi^* D_{\varphi'} = 0$.) This conclusion follows immediately from the mere fact that the energy of the electron interaction is of the same order of magnitude, as their own energy, and therefore the theory of the non-interacting electrons gives the correct order of magnitude. The main problem of the theory of metals we are interested in is, aside from the calculation of the numerical values, the study of the temperature dependence and of the symmetry of the properties of metals. If all the electrons were excited, the energy of the thermal excitation would be of the order NkT, while the Nernst principle requires $\sim \frac{(NkT)}{E_0}$; hence only the fraction $\frac{NkT}{E_0}$ of the electrons is excited. The change of the energy (13) at this excitation consists of two parts: the changes of the first and of the second terms, which are additive, and the change of the third term. This latter change itself may be divided into two parts: the terms, containing the changes of such products $D_\varphi^* D_{\varphi'_\alpha;\, \varphi_\beta + \varphi_\alpha - \varphi'_\alpha}$ which depend on one varying argument φ_α, these terms being also additive; and the terms, containing the changes of the products with two varying arguments φ_α and φ_β, these terms being not additive. The «fraction of the excited electrons» is in our case the fraction of the arguments φ, for which the dependence of the coefficients $D_{\varphi_1 \varphi_2} \ldots$ on them is appreciably altered. When it is small, e. g. equal to $\eta \ll 1$, the additive term of the energy change is proportional to η and the non-additive term is proportional to η^2, since all the three summands in (13) are of the same

order of magnitude, as we have seen. This fact proves that owing to the screening and to the «spreading over» of the electron charges the interaction energy of the electrons, located in the diffuse part of the Fermi distribution curve, is less than the own energy of these electrons in the ratio $\frac{NkT}{E_0}$, and not in the ratio $\left(\frac{NkT}{E_0}\right)^{1/3}$, as might be suggested according to § 2. Hence this energy is of the order of magnitude $E_0\left(\frac{NkT}{E_0}\right)^3$, while the additive part of the energy is of the order $E_0\left(\frac{NkT}{E_0}\right)^2$. Neglecting the non-additive part and summing each term of the additive part over all non-altering arguments, we may write

$$E = E_0 + \sum \varepsilon_j. \tag{15}$$

This is just the fundamental formula of the theory of non-interacting electrons. This formula does not hold in the cases when the zero energy changes essentially, for instance at the Curie point.

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PHYSICS

INFLUENCE OF TEMPERATURE ON EXTINCTION FO PHOSPHORS

By W. ANTONOV-ROMANOVSKY

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The extinction of phosphors belonging to the type of alkaline earths which are activated by heavy metals, depends very strongly on the temperature (1). The exposure of these phosphors to a light of a definite wave length calls forth a photoeffect in the centres of phosphorescence (2) which thus become excited. Experiments have shown that the extinction proceeds on the bimolecular scheme (3). The recombination of an excited centre with an electron can occur only when the latter approaches it sufficiently near. Hence it follows that before recombining the photoelectrons travel through the crystalline lattice of the phosphor long paths, the order of magnitude of which is equal to the mean distance between two neighbouring excited centres, i. e. 10—100 and more atom diameters.

According to current views, the electrons once within a semi-conductor (phosphor), remain there chiefly in bounded state (4). If by w_T we denote the probability of an electron being free, the rate of the exhaustion of luminescence-power will be proportional to w_T. The dependence of extinction on temperature is, however, not limited by its influence on the concentration of free electrons. This becomes particularly conspicuous in the case of high temperatures, when along with the process of acceleration of luminescence-power exhaustion there arises a process of annihilation of the luminescence properties of the phosphor (5).

In the present paper we confine ourselves to the investigation of the dependence of the extinction curves on the magnitude w_T, neglecting the influence of all other factors. In doing so, we necessarily disregard the domain of high temperatures. As to the domain of low and medium temperatures, we may expect that the influence of other factors is comparatively small and that it may be neglected *. The dependence on w_T must be, on the other hand, very considerable. In the simplest case

* So, for instance, the insignificant displacement of the radiation spectrum into the region of red light at the heating of phosphor (6) (a few mμ for 100°) enables us to assume that the recombination probability p_0 of a free electron situated in the vicinity of an excited centre depends also but weakly on T. But even if p_0 depended noticeably on T, this would not play any considerable rôle, except, perhaps, of the very first moments of light emission, since the length of extinction depends chiefly on the time $\left(\text{which is} \gg \frac{1}{p_0}\right)$ spent by the electron to approach an excited centre.

when the localization energy of the electron is equal to ε, we have ([5]) *.

$$w_T = Ae^{-\frac{\varepsilon}{kT}}, \qquad (1)$$

where T is the absolute temperature, k — Boltzmann's constant and A — a quantity depending on T, but under usual circumstances so weakly, that it may be considered as constant (therefore it is convenient to assume $A = 1$). Since the order of magnitude of ε is 1 Ve **, and consequently the rate of recombination depends very strongly on T (for instance, if $\varepsilon = 0.5$ Ve, $T = 300°$ abs., a variation of T only for 10% produces a change of w_T approximately in the proportion of 1 : 100).

Denote by n_1 and n_2 the concentrations of excited centres for $T = T_1$ and $T = T_2$ respectively. Let the conditions of excitation be in both cases quite similar *** and let the initial moment for $t = 0$ be $n_1 = n_2$ ****. If $T_2 > T_1$, the extinction will proceed in the second case faster than in the first. Since for $T = T_2$ the probability of an electron being free is $\frac{w_{T_2}}{w_{T_1}}$ times greater than for $T = T_1$, the extinction velocity will be also as many times greater. Therefore the curve showing the dependence of the concentration n of excited centres on the time t will be in the second case similar to that of the first case, being only, in comparison to this latter, compressed along the axis of abscissae in the ratio of $\frac{w_{T_2}}{w_{T_1}}$ *****. Consequently, the curve expressing the change of concentration of excited centres (light sum) with time in the variables n and $x = tw_T$ will be invariant with respect to the temperature variations, i. e.

$$n = n(x), \qquad (2)$$

where $x = T \cdot w_T$ does not depend on T. Hence, observing that the intensity of phosphorescence $I = -\frac{dn}{dt}$, we find that

$$I = -\frac{\partial n(x)}{\partial x}\,\frac{dx}{dt} = F(x) \cdot w_T,$$

where F does obviously not depend on T. This equation may be also written in the form

$$\lg I - \lg w_T = f\{\lg x\}, \quad f = \lg F,$$

where f does not depend on T. Passing back to the variable t. we find

$$\lg I - \lg w_T = f\{\lg t + \lg w_T\}. \qquad (3)$$

Hence it follows that with T changing from T_1 to T_2 the extinction curve in the coordinates $\frac{\lg I}{\lg t}$ does not change its form, but is only parallelly translated by $\Delta_t = -\lg\left(\frac{w_{T_2}}{w_{T_1}}\right)$ along the axis of abscissae and by

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* This formula is founded experimentally. For instance, the mobility of electrons in alkaline haloid crystals is, according to Smakula ([7]), $v = v_0 e^{-\frac{\varepsilon}{kT}}$, where $e^{-\frac{\varepsilon}{kT}}$ is to be interpreted as the probability of the electron being free.

** According to the experimental data ([7]).

*** It is best to make the process of excitation very short (instantaneous) in comparison with the period of extinction.

**** This condition is necessary, since the shape of the extinction curve depends on the original concentration of the excited centres.

***** This may be proved quite rigorously.

$\Delta_I = +\lg\left(\frac{w_{T_2}}{w_{T_1}}\right)$ along the axis of ordinates, i. e. (since $\Delta_I = -\Delta_T$) it is parallely translated in this direction bisecting the second and the fourth quadrants by $\Delta = \sqrt{\Delta_t^2 + \Delta_I^2}$ upwards, if $T_2 > T_1$, and downwards, if $T_2 < T_1$.

The results obtained may be compared with those derived from experiments, the more so as they do not depend on the particular form of the function f. Should experiments show that formula (3) is not true, for instance that the form of the curve of extinction $\left(\text{in the co-ordinates } \frac{\lg I}{\lg t}\right)$ changes, i. e. that $f = f_T$, or that the parallel translation of the curve is such that $\Delta_T \neq -\Delta_t$, then we could conclude that in the given interval the temperature considerably influences some other factors, on which extinction depends. It often occurs that although the form of the curve of extinction does not depend on T (within certain limits of its variation), its form is such that it is difficult to decide whether $\Delta_I = -\Delta_t$ or $\Delta_I \neq -\Delta_t$. In fact, if the extinction proceeds according to the hyperbolic law $I = At^{-\alpha}$, then

$$\lg I = -\alpha \lg t + \lg A, \tag{4}$$

In this case the curve of extinction in the coordinates $\frac{\lg I}{\lg t}$ is simply a straight line. Since a straight line may be translated into one parallel to it in an infinity of ways, we can always find a translation, for which $\Delta_I = -\Delta_t$. But whether the displacements Δ_I and Δ_t so obtained correspond to the actual ones, is a question which requires special consideration. Therefore, in the case when extinction proceeds according to the law (4), it is more convenient to calculate not the displacements Δ_t and Δ_I, but the displacements Δ_n calculated along the normal to the straight line. The comparison of formulae (3) and (4) shows that f must be a linear function of $\lg t + \lg w_T$, i. e. $f = -\alpha(\lg t + \lg w_T) + c$. Hence

$$\lg I = -\alpha \lg t + (1-\alpha) \lg w_T + c, \tag{5}$$

where c does not depend on T. From (5) we obtain

$$\Delta_n = \frac{\alpha - 1}{\sqrt{1+\alpha^2}} \lg\left(\frac{w_{T_2}}{w_{T_1}}\right). \tag{6}$$

When $\alpha = 1$, $\Delta_n = 0$, i. e. the temperature seems to have no influence on the extinction. If α is nearly 1, the displacements should be very small. This we have found [8] when investigating the extinction of a separate crystal of one ZnS—Cu phosphor. It proved that for T changing from $\sim 25°$ to $\sim 100°$ the curve of luminescence-power exhaustion obeyed the law (4) quite satisfactorily in the measured time interval from $t \approx 0.5$ sec. to $t \approx 400$ sec., α being equal to 1.2. Hereby the displacements of the curve for different T were insignificant. If we apply the formulae (1) and (6), we find $\varepsilon = 0.1$ Ve *. This value differs considerably from the one calculated by us for higher temperatures (from $T \approx \approx 150°$ to $T \approx 250°$). We found then $\varepsilon = 1$ Ve, i. e. 10 times as great! This may be explained by the fact that beginning with $T = 150°$ and higher the curve of extinction suffers considerable changes — from a hyperbola with $\alpha = 1.2$ to a hyperbola with $\alpha = 2$, i. e. that new factors influencing the luminescence begin to play a rôle **.

* The displacements are so small that the error in the determination of Δ_n may reach 50%.

** It is possible that ε may sometimes depend on Δ_n.

On the other hand, the investigations of Levshin and Rickman with powdered CaS—Sm phosphor (from $T \approx 25°$ to $T \approx 250°$), the extinction of which proceeded constantly according to the law (4) with $\alpha \approx 1$, have shown a noticeable displacement of the extinction curve with changing T, although Δ_n should, according to (6), be equal to zero. In this case, consequently, T influences not only w_T even at room temperature.

In 1935 we [9] have investigated the extinction of separate crystals of different ZnS—Cu phosphors. The extinction of large crystals proceeded mostly in quite good agreement with the law (4) with $\alpha = 2$. If we apply to the obtained results the formula (6), we find the following table of ε values (T changed from $\sim 20°$ to $\sim 80°$ C).

ZnS—Cu phosphor	№ 1	№ 2	№ 3
ε, Ve	~ 0.3	~ 0.35	~ 0.3

It should be noticed that for phosphor № 2, whose extinction at later stages went on according to the exponential law * $I \approx e^{-\frac{t}{\tau}}$, we determined the dependence of τ on T. Since $\frac{1}{\tau}$ is considered as a quantity proportional to the recombination probability of electrons with excited centres, we may put $\frac{1}{\tau} = \frac{1}{\tau_0} \cdot w_T$. By (1) we find $\varepsilon \approx 0.3$ Ve. This shows a good agreement with the value $\varepsilon \approx 0.35$ Ve (table) calculated from the displacement of the hyperbolic part of the curve of extinction.

The investigations of Parfianovich (from $T \approx 50°$ to $T \approx 100°$) concerning the inhibition of phosphorescence in crystals of NaCl activated by Ni ** have shown that it proceeds according to the simple bimolecular scheme

$$I = I_0(1 + pn_0 t)^{-2}, \quad I_0 = pn_0^2, \tag{7}$$

where n_0 is the concentration of excited centres at the time $t = 0$ and p is a quantity proportional to the recombination probability of the photoelectron with an excited centre. It proved that the dependence of p on the temperature is exactly determined by the formula (1) with $\varepsilon = 2.1$ Ve, so that $p = p_0 w_T$. It may be easily seen that if $p = p_0 w_T$, the formula (7) is a particular case of formula (3).

The experimental data discussed in the present paper show that our formula (3) explains them in a number of cases quite satisfactorily. Unfortunately the known quantitative results are as yet insufficient for the determination of limits within which the formula (3) may be applied.

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* Such a law of extinction does not contradict the bimolecular recombination scheme of electrons with excited centres [10].

** Ni was introduced inside the natural rock-salt electrolytically at high temperatures.

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CHEMISTRY

ABSORPTION SPECTRA OF COMPLEX PLATINUM COMPOUNDS

By A. V. BABAYEVA

(Communicated by N. S. Kurnakov, Member of the Academy, 11.VI.1938)

Among the inorganic compounds whose absorption spectra have been studied in various spectrum fields, special interest belongs to complex compounds the theory of which has been worked out by Werner and his school. The outstanding interest of these complex compounds is due to the fact that they comprise every description of chemical bonds and play an important rôle in the solution of problems dealing with the very nature of the chemical bond.

From the experimental data to be found in the literature on the subject accumulated by a number of investigators, such as Hantsch, Ley, Samuel, Lifschitz, Schlesinger, Mead, Shibata, Uspensky and others, as well as on the ground of purely theoretical considerations, the conclusion should be made that the character of the absorption spectra of complex compounds in various parts of the spectrum is not only influenced by the nature of the central atom and the intraspheral substitutes, but is also affected by the very spacial pattern of the complex as well as by the character of the bonds between intraspheral groups and their central atom.

The object of our investigation consisted in tracing systematically, how the absorption spectrum in the ultra-violet region is influenced by the number and the location of amino-groups within the internal sphere and both by character and number of acid substitutes and cis-trans-isomerism.

The investigations were conducted with the help of a Fuess quartz spectrograph through simultaneous photographing of the spectrum of the solution and the solvent with subsequent photo-measurement with a Crusseau microphotometer.

The complex compounds of platinum were taken as the experimental material. Indeed, the compounds of platinum and the metals of its groups present the most convenient experimental material for the study of various problems concerning complex compounds, since they possess much greater stability compared with the complex compounds of other metals. A number of regularities characteristic of complex compounds, such as the law of Peyronet, Yergens and Kurnakov, as well as the hypothesis of trans-influence of Cernjaiev, have been deduced while using none other but platinum compounds.

Taking for our starting point the tetramine of platinum $[(NH_3)_4Pt]Cl_2$, we synthesized a number of compounds in which the ammonia of the internal spheres was consecutively replaced by acid groups; whereupon we investigated the absorption spectra of these compounds (Table 1).

Table 1

Experimental material	Location of maximum of bands in mμ						
$[(NH_3)_4Pt]Cl_2$				290			
$[(NH_3)_3ClPt]Cl$				335		281	
$[(NH_3)_3NO_2Pt]Cl$				335		282	256
$[(NH_3)_2Cl_2Pt]$ cis		←442		333	288		
$[NH_3Cl_3Pt]K$	←450			334		280	
$[PtCl_4]K_2$	←453		340			282	
$[PtCl_3NO_2]K_2$	←450			332	287		267
$[Pt(NO_2)_4]K_2$	←453			335		284	264
$[PtCl_6]K_2$	←453			334	289		264

Tetramine $[(NH_3)_4Pt]Cl_2$, as will be seen from the table and curve, has in the ultra-violet region but a single characteristic absorption band with a maximum at 290 mμ.

This band does not depend upon the character or the number of the intraspheral substitutes. It is available with both tetramine $[(NH_3)_4Pt]Cl_2$ and chlorplatinite $K_2[PtCl_4]$, as well as with all the intermediate compounds. Moreover, it has been detected with the cyanides of iron, cobalt, chromium, ruthenium, rhodium and palladium.

Upon the successive substitution of ammonia in tetramine by acid groups (chlorine or a nitro-group), there appeared a new absorption band with a maximum ranging from 335 to 340 mμ.

In the literature on the subject some indications are to be found which would point to the fact that the presence of intraspheral chlorine causes the appearance of absorption bands with a maximum at about 500 mμ. In most cases with the presence of co-ordinate chlorine, in the complexes under our consideration there was to be observed a sharp rise of the absorption curve beyond 450. As the maximum lay presumably in the visible region, we were unable to establish its position with sufficient precision and, therefore, designated its location by an arrow pointing in the direction of the long wave length region. A rise of the absorption curve at the end fringing upon the long wave length region was also observable in those cases when a nitro-group acted as the intraspheral substitute instead of chlorine.

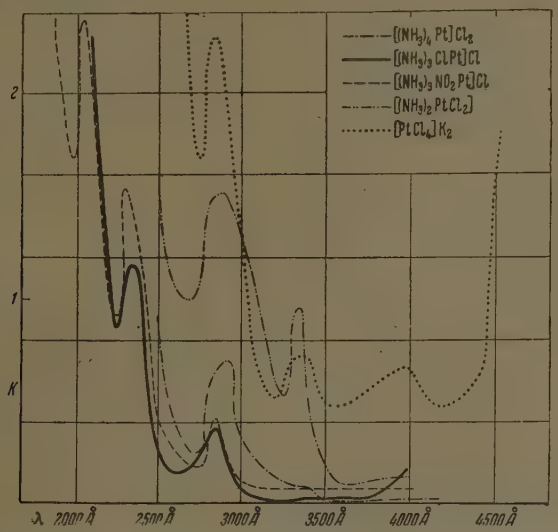
With an increase of the number of acid intraspheral substitutes to 3 or 4, a new, but not always distinct, maximum appears of the order of 400 mμ. A comparatively narrow absorption band with a maximum of about 265 was found in all those compounds which contained a nitrogen-containing group acting in capacity of an acid substitute. The same band was also observed by Samuel and co-workers in complex cyanides; it is quite possible that it may be caused by a valency bond through nitrogen.

Table 2.

Experimental material	Location of maximum of bands in mμ						
$[(NH_3)_3NO_2Cl_2Pt]Cl$	442		(400)		335	284	267
$[(NH_3)_2NH_2NO_2Cl_2Pt]$	←450	424		392	331	282	266
$[(NH_3)_4NO_2ClPt]Cl_2$	←453				337	281	267
$[(NH_3)_3NO_2NH_2ClPt]Cl$	←453		410		335	286	266
$[(NH_3)_3Cl_3Pt]Cl$	←452		402		338	285	272
$[(NH_3)_2NH_2Cl_3Pt]$	442		395		325	272	260

This band is, for instance, wanting for $[(NH_3)_3Cl_3Pt]Cl$, but it is available with the respective amide $[(NH_3)_2NH_2Cl_3Pt]$, in conformity with the transition of ammonia to the acid amido-group (Table 2).

Upon comparing the absorption spectra of the cis- and trans-isomers of bivalent platinum (Table 3) no marked difference in the position of the maximum was noticed.



In the ultra-violet region isomerism does not make itself manifest to any appreciable degree—a fact which is duly noted in literature. It is nevertheless worth remarking that the molecular coefficients of absorption with cis-compounds are greater than with the respective trans-forms.

Table 3

Experimental material	Location of maximum of bands in mμ				
$[(NH_3)_3PtCl_3]$ cis		422	333	288	
$[(NH_3)_2PtCl_2]$ trans			338	278	
$[(NH_3)_2NO_2ClPt]$ cis	453	417	338	286	264
$[(NH_3)_2NO_2ClPt]$ trans		420	340	282	266
$[(NH_3)_2(NO_2)_2Pt]$ cis		422	335	288	265
$[(NH_3)_2(NO_2)_2Pt]$ trans		424	338	297	270

From the Table 3 and the respective absorption curves it will be seen (only a few curves are plotted as examples) that the magnitude of the charge of the central atom does not affect the character of the spectrum in the ultra-violet region.

On the whole, the results of our investigations on the absorption of light in the ultra-violet region of the spectrum by complex compounds of platinum agree well with the data available in the literature for the complex compounds of other metals. However, it is as yet too early to draw any definite conclusions, as the experimental material is still far from being sufficient. Further investigations on a large scale are needed advancing as far as possible into the short wave length region of the spectrum.

In the light of our investigations—so far conducted on a modest scale—as well as on the basis of the evidence from other sources it would, however, follow that the appearance of new bands in the ultra violet region, formerly attributed to a definite component of the complex, does in reality not belong to the action of that complex alone. The difference in energies of electronic therms is caused by a definite configuration of the electrons belonging to the central atom together with the substitutes, and every shifting of the bands is to be understood, according to Pauling's conception, as a change in the energy of co-ordination, whose magnitude, beyond all question, depends both upon the central atom and the co-ordinated radical, while the consecutive replacement of one radical by another should necessarily be attended by a gain or loss in energy which should involve a change in the position of absorption bands.

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GEOCHEMISTRY

ON THE CONTENT OF RARE EARTHS IN THE KARA-TAU PHOSPHORITES

By S. A. BOROVICK and T. A. BUROVA

(Communicated by A. E. Fersman, Member of the Academy, 20.VI.1938)

The great economic importance of the recently discovered phosphorite deposits of Kara-Tau fully justifies the interest manifested to this useful mineral and the tendency to make it the subject of an exhaustive study. A spectroscopic study of the composition carried out by one of the authors has revealed the presence of rare earths in a number of samples obtained from P. L. Bezrukov. Further on, the sum of rare earths was separated out, for which purpose the sample (3.114 g) was decomposed with hydrochloric acid, the insoluble residue filtered off, and the rare earths+calcium precipitated in the filtrate from an acid oxalic acid solution. The oxalates were filtered off, burned to oxides, and the oxides of rare earths+calcium were dissolved in HNO_3. In the solution, the rare earths were separated from calcium by a twice repeated precipitation with ammonia. The hydrates of rare earths were dissolved in NHO_3, and precipitated in the solution of rare earths with oxalic acid. The weight of rare earths oxides obtained was 0.0042 g, which constitutes 0.13% of the original product. The colour of the oxides is a yellowish one, which points to a low cerium content.

№ of element and symbol	Element	Comparative intensity of lines
39 Y	Yttrium	Very strong
57 La	Lanthanum	Medium intensity
58 Ce	Cerium	» »
59 Pr	Praseodymium	Weak »
60 Nd	Neodymium	» »
62 Sm	Samarium	» »
63 Eu	Europium	Very weak
64 Gd	Gadolinium	Weak
65 Tb	Terbium	Traces
66 Dy	Dysprosium	»
67 Ho	Holmium	»
68 Er	Erbium	Weak
69 Tu	Tullium	Traces
70 Yb	Ytterbium	Medium intensity

Further on, the product obtained was again subjected to a spectroscopic examination. This method is the most expedient, as shown by one of the preceding papers of the present authors ([1]). While in the spectrogram of the original product only faint lines of elements present in a small amount, namely yttrium and ytterbium, were observed, the spectrograms of the oxides of rare earths elements showed the full composition of the rare earths group.

The table gives the ultimate results of the spectroscopic study of the composition of the separated sum of rare earths of the phosphorites of Kara-Tau.

Of the rare earths elements № 61 and № 71—lutecium—have not been discovered.

Already on the spectrograms of the original product, the higher intensity of the lines of the elements of the yttrium group—yttrium and ytterbium—was marked, the lines of lanthanum and cerium being absent. Further on, by comparing the intensities of lines on the spectrograms of phosphorite and apatite, taken under identical conditions, it has been possible to confirm that in the phosphorite under investigation the yttrium group is prevailing (in contradistinction to the Khibiny apatite).

Comparing the data of the rare earth content in the Kara-Tau phosphorite, obtained by the authors, with those obtained by I. D. Starynkevich-Borneman ([2]) for a number of the USSR phosphorites, the Kara-Tau phosphorite should be referred to the category of those with an average rare earth concentrations.

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GEOCHEMISTRY

ON A NEW GRAPHITE DEPOSIT IN THE REGION OF KRASNAYA POLYANA IN NORTH CAUCASUS

By A. G. TITOV

(Communicated by A. E. Fersman, Member of the Academy, 20.VI.1938)

In the summer of 1937 the present author was sent by the Moscow Pedagogic Institute to North Caucasus along the route Ashe—Sochi—Khosta—Adler—Krasnaya Polyana. One of the geological excursions was undertaken to the environs of Krasnaya Polyana to a roofing slate mine.

There are references to deposits of these slates in the papers of differents authors; they have been studied particularly in detail by Koifman (2) who was concerned especially with a description of their physical and technological properties. Exposures of roofing slates in this locality are known at several points. A considerable part of them are concentrated in the basin of the Mzymta river and its tributaries.

Opinions differ as to the age of the slates, most investigators being inclined to assign them to the Jurrasic*. Such a difference of opinions is chiefly due to the degree of metamorphization undergone by these rocks. From the observations available it has been established that particularly metamorphosed varieties are nearer to the main range, being developed in the region of Krasnaya Polyana—Achipse—Pslukh in which these deposits are located.

At the same time these slates possess rather complicated tectonics; in many cases they are crumpled in folds and often transected by dark effusive rocks.

The author's observations in the area of roofing slate deposits refer only to one place, namely, to the exposures of these rocks in the region of the Psekokho ridge, where now they are being mined with the aid of tunnels**.

Mineralogically, this place is of some interest owing to the occurrence of small amounts of graphite. This mineral is confined to quartz segregations, which have here the form of stringers.

In the existing literature there are no direct indications as to the segregation of graphite. Up to the present these places seem to be but little studied.

True enough some authors rather vaguely point to the occurrence of some coaly substances among the roofing slates described. Thus, for instance, in the above-cited paper of Koifman (3) mention is made of metamorphosed slates with a considerable content of coaly matter. Along with this, the same paper contains mineralogically valuable data, concerning quartz and mica. Thus, for instance, it is noted that slate not unfrequently contains a considerable amount of mica closely connected with the coaly matter between the bands of which quartz is included in the shape of lenticular segregations. Sometimes together with quartz a small amount of calcite is observed; the two minerals have the shape of small lenses arranged between the coaly bands.

A direct hint to graphite is made by Koifman only when speaking of the exposures between the stations of Ashe and Lazarevskaya of the Cherno-

* Information on the geological structure of the Krasnaya Polyana region see (1).

** This ridge is a continuation of the great Pseashkho range.

morskaya (Black Sea) railway. Here these exposures are represented by siliceous limestones accompanied by segregations of calcite, quartz and graphite. Graphite, according to this author's descriptions, «is represented here by elongated crystals displaying a random arrangement, met both separately and in small accumulations» (4).

In a somewhat later work by Pokrovsky (5) we find also but very fleeting indications with regard to this mineral. This author points to that within the Azov-Black Sea region graphite is as yet known only in the shape of coaly-graphitic shales along the Mzymta river, and of quartz-graphite shists in the Krasnaya Polyana region. The small deposits of graphite, situated about 6 km from the tourist station Krasnaya Polyana upward the river Mzymta, seem to remain till now totally unstudied*. From observations covering a brief period of time the following statements may be made:

1. Nearly at all of the points observed graphite is confined to clay shales and occurs together with quartz inclusions. It has a dense texture and the shape of lenticular or stringer-like segregations.

2. As to its physical peculiarities the graphite is characterized by the absence of macrocrystalline structures, its appearance being that of continuous masses. In many cases ferruginous coatings are observed on the surface of the graphite, consisting primarily of brown iron oxide.

3. In two samples of graphite it was found possible to determine both total content of volatiles by burning the samples in an open tube, and total ash content. The results of determinations may be presented as follows:

1st determination		2nd determination	
Total loss on ignition	88.13%	Total loss on ignition	86.33%
Ash	12.34%	Ash	14.16%
	100.47%		100.49%

In conclusion it should be mentioned that, as already noted, the present deposit of graphite is of purely mineralogical interest, owing to its insignificant size. Of particular interest is the origin of the deposit. There is no doubt whatever that the segregation of graphite here is most intimately connected whit those clay shales, which are coal-bearing in these localities.

Most probably the carbon of the graphite, during the processes of metamorphization, might be concentrated in these small pockets from the dispersed organic matter of the old sedimentary rocks. Cases of similar formations are known in a number of individual deposits when particles of coaly, humic or generally altered organic matter which have found their way to the sedimentary rocks, during the decomposition of some organisms, are subsequently accumulated in the shape of graphite inclusions in the metamorphic formations (6). Observations show that these processes are more intense in those regions of the earth which have a connection with diverse tectonic alterations. There is no doubt that a certain part in this respect could have been played by hot aqueous solutions, the penetration of which contributed to the processes of graphitization.

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* In this year is planned to make a more detailed mineralogical study of this deposit.

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GEOCHEMISTRY

A NEPHELOMETRIC METHOD OF DETERMINING SMALL QUANTITIES OF MERCURY

By A. A. SAUKOV

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In studying the distribution of mercury in various minerals and rocks I found it necessary to estimate quantitatively such amounts of this metal as were too small to be analyzed gravimetrically, escaping the most sensitive microbalances.

There are several methods of determining such small quantities of mercury (millionth parts of a gram). The most sensitive are: the microcolorimetric method of Stock and Tillenius ([1,3]) and the microscopic method of Bodmar and Szep ([1,2,3]). These methods are quite cumbersome and protracted, however, and contain a number of operations during which some mercury may be lost. Consequently, the results obtained after these methods, even when pure reagents are used, are not always satisfactory enough. This was noticed, for instance, by Sinyakova ([4]).

Besides in these methods as well as in others mercury is usually determined in strictly neutral solutions, and the presence of foreign ions hampers these methods and often makes it impossible to apply them without removing these ions which at times requires very complicated operations. Taking all this into consideration I began to look for a method, which would first of all be specific for mercury, secondly, which could be used in acid solutions (this would greatly simplify the work), and which would be sensitive enough.

I turned my attention to a reagent of the composition $NH_4\left[\begin{matrix}(CNS)_4\\Cr\\(NH_3)_2\end{matrix}\right]$ — Reinecke's salt, first described in 1863 ([5]) and studied in detail lately by C. Mahr ([6]) as a specific reagent for bivalent mercury. He applied this reagent in determining significant quantities of mercury gravimetrically.

With solutions of mercuric nitrate and mercuric chloride Reinecke's salt quickly gives a voluminous pale pink precipitate of the composition $Hg\left[\begin{matrix}(CNS)_4\\Cr\\(NH_3)_2\end{matrix}\right]_2$ in which form mercury can be determined gravimetrically in the presence of nearly all the elements, either immediately (after drying at 110°) or by transforming it into Cr_2O_3 by heating. As C. Mahr showed, only Au, Ag and Tl are precipitated out of acid solutions together with

Hg^2 by Reinecke's salt; the following elements, he found, do not give any trouble: Cu^2, Pb, Bi, Cd, As, Sb, Mn, Fe, U, Co, Ni, Al, Cr, Zn, Be, Ca, Si, Ba, Mg, the alkalis and NH_4.

According to our observations, S, Se, Te, In, Ga do not give any trouble either.

Mercury reineckate is very slightly soluble in nitric or weak hydrochloric acid or in a weak solution of aqua regia; therefore the gravimetric method gives good results, which was confirmed by C. Mahr, N. S. Krupenio ([7]) and the author.

The insignificant solubility of mercury reineckate makes this method exceptionally sensitive as well: in nitrate solution (1 : 3) mercury can, for instance, be distinctly detected when the content is 0.2 γ to 1 cm^3, i. e. when the concentration is 1 : 5 000 000. When the concentration of mercury is small, the reineckate precipitates in the form of a homogeneous suspension of very fine particles («turbidity») which show a pale blue or grey (when the concentration is somewhat greater) opalescence, when the test tube with the solution is viewed through in the lateral direction.

I made use of this fact in working the nephelometric method of determining small quantities of mercury.

Reinecke's salt should be taken in newly prepared aqueous solution. Since this solution is pinkish in colour, it should be added in very small quantities (but large enough, of course, to precipitate all the mercury) to the solution which is tested after the nephelometric method: the solution in this case does not attain a pink tint, which would hamper nephelometry. We generally have to do with concentrations from 0.2 to 10 γ per 1 cm^3 and with a solution of about 10 cm^3 in volume, which was poured into the tube of the nephelometer; therefore it is practically, enough to add 1 to 3 drops of a saturated solution of Reinecke's salt to the solution to be tested. The colloidal suspension thus obtained has the most important properties necessary for a nephelometric suspension ([8]).

1. It is very slightly soluble; therefore the reaction is very sensitive.
2. It is quite stable, i. e. the amount of light it reflects during a prolonged time (more than an hour for usual concentrations) is quite constant.
3. If the reagent is not in excess, the suspension may be considered colourless.

The nephelometer which I used was a kind of a Dubosque colorimeter, in which the side walls of the plungers were painted with black asphalt varnish. The observations were conducted in a specially darkened room (a laboratory air drawing box); the source of light was a frosted electric lamp situated 50 cm from the apparatus.

The standards which I used contained: from 0.2 to 6.3 γ of mercury to 1 cm^3 of nitrate solution (1 : 3).

I obtained the best results when the concentration of the solution to be tested and of the standard were about the same. The solutions were compared, as a rule, with two standards—one with a higher and the other with a lower concentration than the test solution; then the average of the two results was taken.

Observing the elementary rules of nephelometration, we obtained quite close results from comparing the solutions with various standards. Thus, for instance, in one of the experiments, when compared with a standard containing 0.63 γ/cm^3, the solution proved to contain 0.51 γ/cm^3; when compared with a standard containing 0.21 γ/cm^3, the same solution showed 0.52 γ/cm^3; when the standard contained 0.32 γ/cm^3, the solution showed 0.49 γ/cm^3 respectively. The average for this solution is 0.51 γ/cm^3. The

results show that the concentration of the solution and the intensity of the light reflected are in proportion (approximately), i. e. that Rayleigh's formula is applicable in these cases. The solutions tested, as well as the standards, were very acid (1 : 3). When the mercury concentration in the solutions was too great (more then 10 γ/cm^3), they were diluted accordingly, since experience showed that the best results were obtained with concentrations between 0.5 and 3 γ/cm^3.

The method of the experiment may be summarized as follows. A definite volume of the nitrate solution under investigation, the concentration of which had been roughly determined beforehand through a quantitative test with a solution of Reinecke's salt, was put into a transparent glass test tube. Two standards of concentrations close to that of the solution to test were put into similar test tubes. Then an equal quantity (1 to 3 drops) of a freshly prepared aqueous solution of Reinecke's salt was introduced into each of the three test tubes. The test tubes were shaken: the solutions became turbid quite quickly and could be transferred after 3—5 minutes into the tubes of the nephelometer and compared. The average of a number of readings (usually about five) taken for the standard and test solutions makes it possible, if the concentration of the standard is known, to determine the concentration of the solution in question.

The experiment showed that if the rules mentioned above are observed, our apparatus permits of determining small quantities of mercury in solution with precision up to $\pm 10\%$, which is shown, for instance, in the table.

Mercury taken (in γ)	Mercury estimated (in γ)	Discrepancy (in γ)
5	5.5	+0.5
7	6.4	−0.6
16	17.1	+1.1
30	30.0	0
50	45.6	−4.4
80	83.6	+3.6

In all these experiments the volume of the solution was 15 cm^3. I used the nephelometric method just described in determining small quantities of mercury in minerals and rocks. For this purpose the substance is reduced to powder, after which from 10 to 200 g of it is put into a quartz tube, which ends in a U-shaped quartz receiver. The tube with the substance is placed in an electric oven and heated for several hours to a temperature of 850°. Air is passed through the tube, and in this manner the mercury is collected in the receiver which is cooled with solid carbon dioxide and acetone to—50° or —60°. The mercury is then dissolved in nitric acid and nephelometrated as described above.

This method may be applied also in a number of other cases when it is necessary to determine small quantities of mercury as, for instance, in air.

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BIOCHEMISTRY

ON THE FERMENT OF PATHOGENIC FUNGI CAUSING THE SPLITTING OFF OF UREA FROM PROTEIN

By K. OVCHAROV

(Communicated by A. A. Richter, Member of the Academy, 18.VI.1938)

Our knowledge of the process of urea formation in higher plants has been considerably extended by the investigations made during recent years. Brunel and Echevin ([6]) found that with the participation of several ferments the process of decomposition of purins accompanied by an accumulation of allantoin takes place in the higher plants, ferments being involved in this decomposition. The discovery of allantoin in the soil made by Shorey ([9]) confirms the deductions of Brunel and Echevin. Previous experiments conducted by Klein and Tauben to ascertain the urea balance in higher plants make us believe that the formation of urea is connected with the decomposition of several arginine-like substances, i. e. such containing radicals of urea.

Urea and its transformations play an important rôle in the nitrogen metabolism of fungial organisms. Phytopathogenic fungi form no exception in this respect, for in the course of their saprophytic and parasitic development they always produce urea ([1,3]) and a small amount of thiourea ([3]).

The ability of some pathogenic fungi to produce urea is markedly increased when they are grown on mediums containing protein. A certain relation between the urea accumulation in a medium and the rate of the growth of the fungus can be observed in this case. One gains the impression as if the fungus prepares the nutritive medium by splitting off with the aid of the ferments the urea from the protein as a ready compound easily assimilated by the organism. The possibility of this process is supported by the experiments of Wada ([10]) who has detected in the milk and liver of herbivorous animals the «reductase», a ferment that is splitting off the urea from the ureides in protein and in other compounds. Nitrogenous metabolism of fungial organisms and the character of the sources of nitrogenous nutrition point to the probability of the presence in fungi of a ferment diureating protein similar to the Wada reductase.

Preliminary experiments, in which the extracts of the fungus and the nutritive medium on which the fungus had been grown have been made to act on protein, showed that the splitting off of the urea in amounts sufficient for a qualitative and quantitative determination takes place in the presence of antiseptics.

Let us describe our method of quantitative determination of the activity of the ferment diureating protein. The following substances were introduced into 4 Erlenmeyer flasks:

Flasks № 1 and 2: medium from the fungus . . . . . 20 cm³
gelatin . . . . . 1.5 g
toluol + chloroform

Flasks № 3 and 4: medium from the fungus . . . . . 20 cm³
toluol + chloroform

All the four flasks were kept for 24 hours at the temperature of 30° C. This period of time is sufficient for the ferment contained in the medium of flasks № 1 and 2 to split off a considerable quantity of urea from the gelatin. Twenty-four hours later 5 cm³ of 10% urease and 5 cm³ of phosphate buffer with pH =6.78 were added to flasks № 1 and 3, after which the flasks were kept for 3 hours in a thermostat at 33°. The ammonia that had accumulated in the flasks was vaporized in a vacuum with milk of magnesia at a temperature of 40—50°. The difference between the respective amounts of ammonia formed in flasks № 3 and 4 pointed to the presence of urea in the medium itself, while the difference between the content of ammonia in flasks № 1 and 2 minus the urea content of the mediums pointed to the intensity of the splitting off of the urea from the gelatin by means of the ferments contained in the medium. To make our calculations explicit, let us take the data of the experiment of 4. V. 1938.

A medium from a monthly culture of *Pythium de Baryanum*, grown on a glucose-mineral medium with edestin as nitrogen source, was taken as the source of ferment. The results of ammonia determination are as follows:

In flask № 1 . . . . . 12.6 mg
» » № 2 . . . . . 7.26 »
» » № 3 . . . . . 6.58 »
» » № 4 . . . . . 6.16 »

Subtracting 6.16 mg from 6.58 mg, we obtain 0.42 mg of ammonia of the urea contained in the medium; the substraction of 7.26 mg and 0.42 mg from 12.6 mg will give us 4.92 mg NH_3 of the urea that has splitted off from the gelatin by means of the fungus ferment. When applying this calculation to urea, we obtain 10.53 mg of same. By this method we determined the activity of the ferments in three pathogenic fungi: *Verticillium albo-atrum*, *Botrytis cinerea* and *Pythium de Baryanum*. *V. albo-atrum* usually develops in the vessels of the xylem, i. e. outside the living cells of an affected plant; *B. cinerea* on fruits, on plant organs rich in reserve substances, but vitally depressed owing to unfavourable environmental conditions, on plants where a one-sided process of protein disintegration is prevailing (4); *P. de Baryanum* affects sprouts and young plants of different species under saprophytic conditions; it assimilates N from various sources and develops particularly well on urea (Dorochova) and on some proteins.

Ferment activity was determined in a nutritive medium by means of water extract of ground fungus (endoferment).

The activity of ferments in pathogenic and saprophytic fungi is not of a permanent nature, being greatly dependent on the composition of the nutritive medium. Of great importance for the activity of many hydrolithic ferments is the introduction of the substances of substratum of fermentative reaction into the nutritive medium: of proteins for the activity of protease, of starch for amylase, of pectins for pectinase, etc. The process of this fermentative adaptation still lacks definitive clearness, although a number of theories bearing on this problem are available [see Oppenheimer (3), and a more recent review by Suchorukov (4)].

We have determined the activity in three pathogenic fungi. Below are given data on the ferment activity of 20-day cultures of *Verticillium albo-*

atrum, *Botrytis cinerea* and *Pythium de Baryanum*, grown on various proteins. The indices of the ferment activity in mg of splitted off urea are given in Table 1.

Table 1

Ferment Activity

Source of nitrogen	*Verticillium albo-atrum*		*Botrytis cinerea*		*Pythium de Baryanum*	
	Mycelium	Medium	Mycelium	Medium	Mycelium	Medium
Edestin *	14.3	0.9	18.9	4.8	70.0	18.9
Glutenin *	1.5	0.0	23.7	3.3	16.8	8.7
Gelatin *	6.6	0.9	20.8	2.0	31.5	1.6

The growth of these fungi on mediums containing edestin, glutenin and casein differed from case to case, the best growth having been exhibited on edestin. The growth of a 20-day culture of *Pythium* and that of *V. albo-*

atrum and *Pythium de Baryanum* may be seen in the Figure and in Table 2, respectively. The growth on nitrate ammonium is shown for comparison.

Table 2

Nitrogen source	Dry weight of mycelium in g	
	Verticillium albo-atrum	*Pythium de Baryanum*
Edestin	1.150	2.490
Casein	0.820	2.330
Glutenin	0.730	2.050
Gelatin	0.200	1.630
NH_4NO_3	0.080	0.210

The ferment under investigation is, evidently, of high importance for nitrogen assimilation from protein by fungi, especially in the first period of their development when the fundamental hydrolitic processes are still in progress.

* Edestin was obtained from common hemp, glutenin from wheat flour; the proteins were prepared according to Osborn; the gelatin was that in common use for microbiological mediums.

Previous investigations, made at the Institute of Plant Physiology of the Academy of Sciences ([5],[1],[2],[3]) have shown that toxic excretions of pathogenic fungi contain ammonia, urea and thiourea.

The toxicity of urea for higher plants was also established by David ([7]) who studied the effect of urea on the sprouts of certain of them. In our communication we describe one of the particular cases of urea formation by pathogenic fungi. We succeeded in detecting the ferment of fungi by which urea is splitted off from protein in a nutritive substratum. We suggest for this ferment the name of deurease.

The activity of deurease depends on the nitrogenous composition of the nutritive medium and, in case of use of proteins, on the nature of the latter. Deurease is being excreted by fungi into the nutritive medium, but the greater part of it is preserved in mycelium as endoferment.

The properties of deurease and its effect upon various plant proteins will be the subject of our next paper.

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BIOCHEMISTRY

PHYSICO-CHEMICAL INVESTIGATION OF COCKLEBUR OIL

By N. MAXIMOV

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The Soviet oil and fat industry has in a comparatively short time created considerable resources of raw material which will secure for our country in the nearest future a foremost position in the world production of oils.

However, we ought to acknowledge that many wild growing plants among the flora of the USSR remain as yet unstudied and untested under this aspect.

Yet, such branches of industry as production of paints and varnishes, soap-boiling, production of synthetic rubber etc., are in want of vegetable oils. This shortage could be easily filled up by introducing into practice new kinds of raw material that are to be found among the wild growing flora.

To solve this problem we undertook an investigation of the local wild growing oil-bearing plants, testing the latter for fatty oils content.

One of those profitable plants, deserving great attention because of its high oil content and the economic value of same, proved to be cocklebur, a plant, occupying large areas in the vicinity of the town Cheboxary, on wastes, weedy soils, in the streets of this town, and on sandy river banks.

Botanically cocklebur is an annual plant belonging to the family of compositae (*Xanthium strumarium* L.). Its fruits are hard and bini, each of them containing two achaenes which are rather large in size, somewhat reminding those of eatable sunflower.

In special literature cocklebur has been referred to only as a weed, nothing being known as to the oil-bearing quality of its fruits. Strange enough, even the Proceedings of the Gorky District Scientific Institute for Socialist Agriculture, issued in 1935 under the title «Wild growing oil plants of the Gorky District», contain no information as to cocklebur.

In the course of our work mentioned above, the fruits of cocklebur were subjected to analyses as peeled achaene.

The oil was extracted from achaenes by means of sulphuric ether, using the «Soxlet» apparatus; the procedure lasted for 10 hours, the number of drainings being 2½ per hour, after which the oil was dried in a jet of CO_2 at a temperature up to 100° C.

Iodine number was determined by the method of Hübl, number of saponification and acid number after the methods usually adopted in the chemistry of fats.

In order to obtain a film, an objective glass was covered with a layer of oil (not drying oil), and put do dry in a thermostat during 3—4 days

at a temperature 30° C. Being exposed for one month to sunlight, such a film did neither chap, nor change its colouring.

The water-absorbing capacity of the film was determined by the method of weighing. A previously weighed film was plunged into water for 3 days. After this lapse of time it was taken out, dried cautiously on filter paper, and weighed again, its absorbing capacity being determined after the formula devised by OST 1775. The physico-chemical qualities of cocklebur oil, as seen from the table below, narrowly resemble those of poppy oil. Its colour is light-yellow, its consistence liquid and transparent, it is palatable and has a pleasant smell, its test and smell approaching those of sunflower oil.

Oil content in achaene in % to absolutely dry matter	Acid number	Saponification number	Iodine number	Water-absorption capacity in %
38—40	2.1	198.2	140.3	0.22

As the quantity of cocklebur oil at our disposal was insufficient, its physico-chemical characteristics contains but scanty data. Nevertheless, they suffice to solve the question as to its practical fitness.

All the data stated above permit of drawing the following conclusions:

1. Cocklebur belongs to those species of plants, the achaenes of which contain a considerable amount of oil of high industrial value.

2. Owing to its high iodine number and its driability, cocklebur oil can be successfully applied for production of drying oils, for soap-boiling, and, possibly, like that of most compositae, for food purposes too.

3. Attention should be paid not only to the driability of cocklebur oil, but also to its forming a thin, tough, transparent and lustrous film which makes it applicable for the production of valuable varnishes and paints, and, possibly, allows to use it when painting the submarine parts of vessels.

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GEOLOGY

ON THE AGE OF THE DZHEZKAZGAN SERIES

By D. SAPOZHNIKOV

(Communicated by V. A. Obruchev, Member of the Academy, 3.VI.1938)

The rocks of the Dzhezkazgan series enclosing one of the largest deposits in the Union, the Dzhezkazgan copper deposit, have been regarded up to recently as unfossiliferous, and their age has been determined on the basis of indirect data differently by different geologists. Thus, the English geologist S. Boll referred their age to the Permian-Carboniferous time; according to I. S. Yagovkin ([3]), the ore-bearing formations of the Dzhezkazgan series were deposited during the Middle Carboniferous; while K. I. Satpaev ([2]) believed that «the accumulation of the Dzhezkazgan series was taking place in the course of all the geological periods, from the Middle Carboniferous to the Permian inclusively». Only the work carried out in 1937 by the Central Kazakhstan expedition, organized by the Council for the Investigation of Natural Resources of the Academy of Sciences of the USSR in the Karsakpay region, gave sufficient material which permit of a more accurate determination of the age of the Dzhezkazgan series.

In the summer of 1937 the author studied a section in the Upper Paleozoic formations in the area of gypsum domes discovered by B. A. Petrushevsky ([1]) and located 100 km southward from the town of Karsakpay. Here at the Kock-tyube dome has been revealed the following succession of beds.

At the base are lying calcareous beds, composed chiefly of limestones, argillaceous and calcareous schists. In the limestones fauna has been found, from which Andronov has determined the following species: *Spirifer* sp. n. (aff. *mortonanus* Miller), *Productus* cf. *mesialis* Hall., *Echinoconus elegans*, *Schizophoria resupinata* Mart., *Sinuatella sinuata* Koninck., *Productus jagovkini* Nal., *Productus ovatus* Hall., *Gigantella* sp. n., *Bellerophon* sp., *Caninia* sp., *Orthothetes kaskaskiensis* Mc'Chesney, *Productus sulcatus* Sow., *Gigantella* sp., *Spirifer duplicicosta* Phill., *Productus tenuistriatiformis* Einor, *Productus (Gigantella) krasnopolskii* Einor, *Gigantella edelburgesis* Phill., *Gigantella coartarus* Einor, *Gigantella krasnopolskii* var. *venusta* Einor, *Productus insculptus* M. Wood, *Caninia* sp. ind., *Leptaena analoga* Phill., *Dielasma* sp. n. (numerous), *Spirifer* cf. *integricosta* Phill., *Cliothyridina* sp. n.

This complex of fauna is an unquestionable evidence of the Upper Visean age of the enclosing rocks. The thickness of the calcareous rocks of the Upper Visean is about 85 m. Higher are lying the following beds.

Layer 1. A pinkish-grey conglomerate, composed of limestone pebbles, bound with calcareous cement. Thickness 1 m.

Layer 2. Alternating red calcareous sandstones, sandy and clayey shales. Occasionally layers of fine-pebbled intra-formational conglometates are encountered. Thickness 80 cm.

Layer 3. Grey, argillaceous siliceous limestone, containing inclusions of black silicon, especially abundant in the upper portion of the layer. Thickness 2.8 m.

Layer 4. Alternating sandstones and clayey shales, resembling those of layer 2. Thickness 9.6 m.

Layer 5. Red, brownish shale enclosing individual calcareous concretions, and a horizon filled with segregations of grey and black flint. Thickness 2.5 m.

Layer 6. A pinkish-grey conglomerate, composed of limestone pebbles. The latter are worn and their size is up to 5 cm; they are cemented with a calcareous substance; upward the conglomerate gradually passes to a sandstone. Thickness 2 m.

Layer 7. Alternating red sandstones and clayey shales. Thickness 180 m.

Higher up rocks of the so-called red beds are lying. These are:

Layer 8. Brick-red sandstones, friable, argillaceous with bands of slightly cemented argillaceous sands. Thickness 64 m.

The rocks of the section under description, from the second layer to the seventh inclusively, resemble the deposits of the Dzhezkazgan series of the Dzhezkazgan deposit region both from their petrographic composition and from their attitude in the section. This resemblance is still augmented by the presence of a calcareous comglomerate band in the section of Mt. Kock-tyube, which may be compared to the Raymund conglomerate of Dzhezkazgan. It should be noted particularly that in the section of Mt. Kock-tyube a band of flints (layer 5) has been encountered, which is very characteristic of the deposits of the Dzhezkazgan series. This band is very persistant in the region of the Dzhezkazgan copper deposit; it has been traced over a distance of several tens of kilometers—it occupies a quite definite stratigraphic position; by the geologists working in Dzhezkazgan it has been named «the hornfels horizon». The finding of the latter in the area of the gypsum domes 120 km southwards from Dzhezkazgan, in the same part of the section as in the north, still emphasized its significance as an important stratigraphical horizon.

When studying the thin-sections of sedimentary rocks from the Kock-tyube section, the author succeeded in discovering microfauna in one horizon. This microfauna has been encountered in limestone concretions of the same layer (5) where the presence of flint («hornfels») bands has been established.

According to the determination made by D. M. Rauser-Chernoussova, the microfauna consists of the following forms: *Archaediscus karreri* Brady, *Archaediscus baschkiricus* Krest. et Teod., *Stafella* ex gr. *struvei* Moell., *S.* cf. *pseudostruvei* Raus. et Bel., *S.* aff. *pseudostruvei* Raus. et Bel., *Climacammina* sp. aff. *patula* Br., *Tetrataxis* aff. *minima* Lee et Chen.

According to Rauser-Chernoussova, the age of the microfauna is referred to the Upper Visean or, possibly, the Namurian.

The intimate connection existing between the faunistical characteristic of the deposits and the flint («hornfels») horizon is of extreme importance. It points to the age both of the flint-horizon and of the thick beds of unfossiliferous ferrigene rocks, lying between these and the faunistically characterized Visean limestones. Between them in the Dzhezkazgan a thick group of strata is lying, whose lower portion consists of green and grey sandstones and shales, and the upper portion—of red sandstones and shales of the Dzhezkazgan series. So far most of the authors referred the former to the Upper Visean and the latter to the Middle Carboniferous.

The discovery of microfauna shows this conception to be erroneous and proves the Upper Visean age of the lower portions of Dzhezkazgan ore-bearing beds, the flint («hornfels») horizon inclusively.

The presence of microfauna in the red beds is very significant for the determination of the origin of the Dzhezkazgan series, whose rocks have so far been regarded as desert deposits. The existence of microfauna in the red beds enables us to assert that at least a part of these in the section under description is not of a continental but doubtlessly of a marine origin.

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GEOLOGY

ON THE QUESTION OF CLIMATES DURING THE QUATERNARY PERIOD OF THE FAR EAST AND ON THE HISTORY OF PERMANENTLY FROZEN GROUNDS

By G. E. BYKOV

(Communicated by V. A. Obruchev, Member of the Academy, 15.VI.1938)

The question of the history and origin of permanently frozen grounds has been repeatedly raised in literature. Outstanding specialists in this field have solved it in the following manner. According to the opinion of Sumgin ([4]), permanently frozen grounds have existed since ancient times on the territory of the Asiatic part of the USSR, and are genetically connected with glaciation of the Quaternary. He states that conditions prevailing on the aforesaid territory are undergoing a slow change toward warming up, and in connection therewith a natural degradation of frozen grounds is taken place. Lvov ([3]), as well as Grigoryev ([1]), also believe that permanently frozen soil is a relic of the glacial period, which once upon a time covered the northern parts of Siberia.

Let us see whether this assumption is in agreement with the history of the country's climates as emerging in the light of new geological data, derived by me and other investigators in recent years. In view of the fact that the Quaternary period of the territory of the Soviet Far East was but with a few slight exceptions (the region of Ussuryisk and other places) a period of predominance of continent, natural enough, the most valuable data on its climate are derived from the nature of the precipitation proper, and chiefly the vegetative remains, preserved in the fossiliferous deposits of this system: It is noteworthy that the fossil flora of the Quaternary deposits is very rarely found in a state of preservation which would allow of its identification; such are isolated findings. However, the deposits we are interested in abound in turfs and silty rocks, frequently containing remains of pollen of trees. Considerable material is accumulated by now, permitting to judge about the character of the vegetation of various stages of the Quaternary. We shall proceed to the survey of the latter.

After the close of the Tertiary period, during which a relatively rich vegetation of warm and warm temperate types (Miocene and Pliocene) covered the Far Eastern territory, at the beginning of the Quaternary time ensues an epoch of predominance of relatively temperate and even cool temperate flora.

We come across the poorest type of vegetation in deposits of the beginning of the Quaternary period, in the third terrace of large rivers (Zay river, Amur and others). The sediments of the latter, being quite uniform in cha-

racter, rarely contain remnants of vegetation. Of that terrace we have studied peat bogs from the vicinity of the settlement Kerby (on the Amgun river). This is the only one outcrop of turfs known from that terrace. In numerous samples of this fossil deposited in small interbeds in the many meter thickness of thinly bedded sands have been revealed remains of the pollen of *Salix*, *Betula* and *Pinus**. The impoverishment of the vegetation of this terrace is no casual phenomenon. It is observed throughout the entire strata and at various sites of this locality. This apparently bears evidence of a depressed growth of arboreous plants, due to the influence of conditions approaching Arctic severity. This viewpoint is in perfect harmony with the character of thin bedded deposits, quite analogous to clay bands of the Leningrad district. They are the same interbeds of alternating fine sand and clay, coloured grey. The latter properties are well traceable and persistent at all places of development of this terrace. Only in the lower parts of the Zay river, among the thin intercalations occur single laminated bands rich in iron oxide and therefore having a reddish colour.

In the upper parts of the Amgun river these deposits are overlain by pebble beds of glacial origin. Thus, from this circumstance we may deduce that the severe conditions of the times of the third terrace deposition were followed by still colder ones, favourable to the formation of glaciers. Traces of the latter are revealed in great numbers in the basin of the aforesaid river.

Unfortunately, it is impossible to trace further the evolution of climate. As usual, in studying geological data, we deal but with fragmentary information, whereupon we tend to reconstruct the general picture. The same is true in this particular case. The period of time extending between the deposition of the afore-mentioned pebble beds and the second terrace deposits could not be characterized until now by any facts which would bear evidence of climate. We have at our disposal but numerous indications referring to deposits of the second terrace, and that chiefly to its upper part. The latter testify to a considerably warmer climate and even, at least in the southern part of the district, to a hot climate. From this terrace, in the lower parts of the river Bureya, Krishtofovitch (2) has collected a fossil flora containing *Ginkgo*, *Zelcawa*, *Betula*, *Ulmus*, etc. In the lower parts of the Amur, the same terrace comprises turfs containing the pollen of *Ulmus*, *Alnus*, *Quercus* and other plants. Likewise a considerably more «thermophilic» character, as compared to the third terrace, is exhibited by the arboreous plants of which pollen has been discovered in peat bogs of other denudations. Additional evidence of warm conditions favouring growth is furnished by fresh water mollusca, found by I. G. Kozlov, with thick massive shells, not at all characteristic of present day conditions prevailing in this region. The red colour character throughout the entire thickness of this terrace is another proof of the hot climate during the times of its formation. In this respect are of interest pebble beds found in the lower parts of the Amgun river—in the deposits of this terrace—covered with a magnificient desert tan. It should also be noted that among its deposits are encountered pale yellow and bright yellow loams (basin of the Zay river). The latter too speak for different climatic conditions, approaching those of contemporaneous steppe land.

Neither the time space between the deposition of the third and the second terrace, nor the epoch following the deposition of the latter, are we able to represent from the point of view of climatic conditions. But already at the base of the first upper Turbarian terrace overlying a flood plain (during disastrous floods it is sometimes inundated by high waters) are revealed turfs,

* The majority of definitions of pollen have been made by E. Smirnova of the Leningrad Academy of Forestry.

containing pollen, though of a more moderate vegetation than the one described above, yet still differing from the contemporaneous. Herein are found *Quercus*, *Pinus pumula*, *P. coraiensis*, *Alnus*, *Betula*, and others. Larch is either absent or of extremely rare occurrence in these strata. Only in the upper parts of its deposits vegetation becomes poorer approaching the present day regime. Oaks disappear, pine trees decrease in number, and larches spring up. The latter is the most widespread arboreal species over a considerable portion of the region at the present time. The indicated changes in the composition of pollen of the first terrace are not casual either. They are retraced in the basin of the Zay river as well as in the left tributaries of the Amur river in its lower course (Amgun river). The transition of vegetation made up of oaks, pines and alders, to a type wherein larch is prevailing and oak missing, was observed also at the watershed marshes of the Upper Zayan plain. The above-mentioned phenomenon is confirmed by collections of algae, from the lake Ogoron, where the disappearance of salt water forms, abundantly represented in a fossil state in ancient deposits, is observed. The type of present-day diatoms of this lake approaches that of algae peculiar to Arctic zones. It is noteworthy that the most ancient deposits of watersheds are also distinguished by this kind of diatomaceae. We are quoting these examples in order to show that the conclusions drawn herefrom, founded essentially on the study of terrace turfs, are far from being incidental, but are supported by studies of other phenomena.

Comparison of contemporaneous vegetation with the results of pollen investigation in fossil turfs should be made with particular caution. The point is that the Far Eastern flora of to-day displays rather variegated composition. Alongside of territories covered with plantations of larches and similar wood species, peculiar to cold climate, this region includes provinces distinguished by more thermophilic vegetation. Such are, for instance, the lower course of the Amur river, where oak and poplar are met, the region of Ussuryisk. The comparison of vegetation of the first terrace and that of to-day has been made by us in those provinces which, owing to severe climate, are at present on their whole territory devoid of plantations of oaks, elms and other trees (as for example, the Upper Zayan plain). It should be noted that similar results were obtained in districts where representatives of warm flora are found now, except that the pollen of the latter is not disappearing in the upper horizon, but only diminishing in amount (the Amur river, near by the mouth); therefore, the operation of such agencies (the decrease of the number of representatives of warm climate in deposits of the first terrace) may assume general significance for the entire region.

The changes observed in the type of vegetation may be referred to supposed changes of climate during the deposits of the first terrace. More or less temperate conditions which predominated during the initial stages of its formation, were gradually succeeded by more severe conditions, approaching the contemporaneous. The change of vegetation ran parallel to the change of climate, gradually taking on the appearance which distinguishes it at the present time.

Thus, we see that the fossilized pollen of plants, and consequently the climate corresponding to it in time, had undergone the following changes during the Quaternary period. The cold subarctic regime of the times of the third terrace formation was followed by a still colder one, favouring the formation of glaciers. Toward the ensuing epoch of the second terrace deposition glaciers disappear. Climatic conditions grow considerably warmer. There appears subtropical vegetation (*Ginkgo*). Naturally enough there is no question of the preservation of permanently frozen grounds there at that time. Further, by the time of the first terrace deposition, conditions of climate change again. They become severe, approaching the contemporaneous. In the time space between the deposits of the first and second terrace might possibly have occurred phenomena of considerable refrigeration, connected, perhaps, with glaciation, but traces of the latter have not been yet revealed. At any

rate, during the deposition of the base of the first terrace, if one is to judge by the vegetation, the predominant climate was more temperate than the one observed now, and it was only gradually changing in the direction of still greater frigidity, toward the contemporaneous. As we see from the aforesaid, the epoch of the dominance of permanently frozen soil is separated in time space by an age of dominant hot subtropics from the only one glaciation discovered in the Far East. From the epoch of the second terrace erosion, about the conditions of which no informations are available, and which may be connected with glaciation, it is also separated by a period of temperate vegetations and climate. The epoch we live in, with its inherent frozen grounds, thus, lacks sequence to be traced back to earlier cold epochs of the Quaternary. The facts indicated above seem to lead to the conclusions that refrigeration took place in the closing stages of the geological history of the country. May be, the latter is very slowly going on still now.

The preservation of the organic matter of various terraces also indicates that frozen grounds have existed perpetually only from the moment of the beginning of the first terrace depositon. The ancient terraces are almost completely devoid of plant remains which would not be decomposed, while the first terrace contains a great amount of vegetative remains, which owe their preservation only to the existence of frozen grounds. The absence of the latter in the epochs of deposition of ancient terraces is testified also by certain forms of their structure and of the relief. However, the description of the latter would get us too far, and therefore we are not describing them here.

It follows from the aforesaid that permanently frozen grounds, at least within the boundaries of the Amur basin, could not be relics from the glaciation period, of which traces have been found in the basin of the river Amgun and Bureya. Its predominance was not distinctive of the entire Quaternary period and is connected in time only with the first terrace of large rivers. It may be possible that the formation of that terrace was preceded by a later glaciation than the one we have mentioned above. But, as indicated, no traces of the latter have been found yet. The conditions favourable to frozen grounds assumed more severity and, perhaps, even originated during the time of refrigeration, which ensued simultaneously with the formation of the first terrace. In view of the fact that no signs of any amelioration of climate conditions, no warming have been observed since that moment (some data testify rather to the reverse), which would have been recorded by such a sensitive barometer, as the character of vegetation, we may believe that the existence of permanently frozen soil is the result of conditions bearing resemblance to those of to-day.

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MINERALOGY

SYNTHESIS AND INVESTIGATION OF BIOTITE

By D. P. GRIGORYEV

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Magnesial-ferruginous micas have been synthesized more than once, from melts(1), possibly from aqueous solutions (2), and found in slags (3,4) and in the contact zone of a glass and refractory material melt (5).

In literature almost to all artificial magnesial-ferruginous micas have been assigned the name of biotite. This denomination is based upon the data of the simplest crystallo-optical investigations (character of pleochroism and magnitude of the angle of optical axes). Only mica synthesized by Chroustchoff (6) and mica from slag, described by Mitcherlich (3), have been subjected to chemical analysis. Both these micas are in reality no biotites. According to the author's chemical classification of micas, they possess the following characteristics: the former 1·0. 1·8·0.17 and the latter 1·0·0.76 and are named fluorphlogopite and fluomeroxene respectively. Thus, it should be understood that artificial micas, whose appurtenance to biotite is based on precise optical analyses and chemical characteristics, have not been described up to now.

In the course of previous experiments on artificial production of micas (1), the author synthesized as early as in 1935 a number of micas from purely magnesial to magnesial-ferruginous, consisting one third of a magnesial and two thirds of a ferruginous component. The present article is confined to the description of the results of the synthesis and investigation of one of the extreme members of this series referring indubitably to fluor-biotite.

Synthesis was made in a platinum crucible in a tube cryptole furnace where the atmosphere is as far as possible approaching a neutral one. The initial mixture was calculated according to the formula $F_4K_2O \cdot 2MgO.4FeO \cdot Al_2O_3 \cdot 6SiO_2$, corresponding to the ratio of the magnesial and ferruginous constituents ($F_2KMg_3AlSi_3O_{11}$ and $F_2KFe_3AlSi_3O_{11}$) as 1 : 2 (the composition is given in the table).

Table 1

Composition	As synthesized by weight of %	As analyzed by weight of %
SiO_2	36.0	—
Al_2O_3	10.2	—
Fe_2O_3	—	0.42
MgO	8.1	—
FeO	28.7	27.67
K_2O	9.4	—
F	7.6	—
Total	100.0	—

It should be noted that fluorine has been introduced into the mixture as NH_4F in thrice the quantity against that calculated, in order to compensate its losses in volatilization. Melting was carried out at about 1450°.

The alloy obtained proved to consist of lamellae of mica almost black (with a brownish tinge), up to 4 mm² in size. Glassy lustre, perfect cleavage; the lamellae are flexible and elastic; hardness—3.

Aside from mica constituting the bulk of the alloy, a dark substance has been revealed in it by optical analysis, filling the interstices between crystals and areas of almost colourless glass with segregations of structures of cristobalite growths. The optical properties of the mica proved to be as follows:

Pleochroism $Y=Z$—brown; X—colourless. Extinction—direct; $2V\approx-0°$; $N_g=1.596\pm0.003$; $N_p=1.551$; $N_g-N_p=0.045$.

A piece of the central portion of the alloy (the isolation of pure mica from the accompanying black substance appeared to be impossible) has been subjected to partial chemical analysis. Since the object of the experiment consisted in the synthesis of biotite, only ferrous and ferric oxide have been determined to test the chemical composition of the alloy. The results of the analysis made by E. N. Egorova are shown in the table.

The chemical analysis shows that in the course of melting of the initial mixture the oxidation of ferrous oxide took place to a minimum extent. From the content of the ferruginous constituent the alloy obtained almost fully corresponds to the theoretical calculation. Since mica is the principal constituent of the alloy, we may assume its composition to be very close to that obtained from calculation; some deviation may, possibly, be put down to the high concentration of ferric oxides in the dark opaque substance.

According to the data of the analysis and to the author's chemical classification the mica synthesized has the following characteristics: 1·0.65·0.04. In this case it must be regarded as a typical fluor-biotite*.

Optical properties partly justify the reference of synthesized mica to biotite (especially the character of pleochroism and a considerable birefrigence) and partly contradict it. The contradiction is in the discrepancy between the content of ferrum oxides in mica and the indices of its refraction which seem to be much to low. Such a discrepancy proves, however, not to exist at all, if the following facts be taken into account.

1. Synthesized mica, biotite, is purely fluoric. The presence of fluorine considerably reduces the refraction of micas (in a limit case for 0.020) which among others has been particularly emphasized by W. Kunitz (7).

2. Synthesized biotite contains a very small amount of ferric oxide. This also leads to a considerable decrease of refraction since from the experiment of F. Rinne (8) may be seen that the oxidation of FeO to Fe_2O_3 sharply increases the refraction indices of micas.

3. Synthesized biotite contains no admixtures which in native micas mostly produce heightening of the refractory indices (especially TiO_2, MnO, NiO, Cr_2O_3).

All these facts, as well as the chemical composition of the alloy, lead us to the conclusion that synthesized mica is practically a typical fluor-biotite.

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* This denomination is retained even in case of considerable deviations in both directions of the «ferruginous» members of the characteristics.

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GENETICS

INVESTIGATION OF THE BLOOD VALUE OF THE YAROSLAV BREED OF CATTLE WITH REFERENCE TO PRODUCTIVITY

By H. F. KUSHNER

(Communicated by N. I. Vavilov, Member of the Academy, 2. VI. 1938)

The object of this investigation was to establish the relation between the blood value and the constitutional characteristics of the Yaroslav breed of cattle and also to ascertain the effect which the oxidative capacity of the blood has on the productivity of cattle.

Analyses of blood were taken at the Uspenskaya Pedigree Cattle Farm (Yaroslav district) during the month of June (1—22) 1937. The analyses covered a herd of 270 thoroughbred Yaroslav cattle. In every case the blood was taken from the jugular vein in the early morning hours after food and water has been withheld from the animals during the whole night.

The analyses were taken by the Sahli method for haemoglobin and by the Nevodov method for reserve alkalinity; the number of erythrocytes was determined using the Thoma-Zeiss camera, the diameter of the erythrocytes after undyed dry smears (100 erythrocytes of each smear were measured), the thickness of the erythrocytes (measured for a small number of animals) was determined by the «thick drop» method.

The results of the analyses are shown in Table 1.

Space does not permit us to give here a detailed analysis of age variation and sexual dimorphism in connection with blood value as revealed by our investigations, but we must point out the following fact. While in the case of adult animals the bulls inevitably show a higher haemoglobin value and a greater number of erythrocytes, in the case of young animals up to the age of four or five months the picture is quite the reverse, the young female calves and not the bullocks showing a higher blood value. In our previous investigations we have shown that the same phenomenon was to be observed among the Kalmuck cattle of the Salsk experiment farm and also among horses and camels in Middle Asia. This offers ground for the conclusion that in this species of animals the higher blood value of the young females evidently represents one aspect of a more general biological regularity, which marks a given age. It may be assumed that this regularity is embodied in a more intense process of metabolism revealed in young females. Insofar as an intense process of metabolism is connected with the energy of growth ([8]), it is easy to understand why at this age young female calves show a greater intensity of metabolism as compared with bullocks. A good many facts relating to the more rapid growth in the case of calves are to be found in ra recent paper by V. M. Dzyubanov and I. M. Klochko ([1]).

Table 1

Blood Value of Cows, Bulls and Calves on the Uspenskaya Farm

Age	Young female calves and cows					Bullocks and sires				
	Number of animals	Haemoglobin content (by the Sahli method)	Number of erythrocytes in millions	Alkalinity reserve	Diameter of erythrocytes in microns	Number of animals	Haemoglobin content (by the Sahli method)	Number of erythrocytes in millions	Alkalinity reserve	Diameter of erythrocytes in microns
Up to 15 days	2	52.9	7.96	450	5.71	5	50.46	7.05	452	5.41
1—2 months	12	45.18±2.09	7.87 ±0.36	454±14.8	5.1 ±0.085	9	44.45±1.35	8.07±0.476	444.6±32	5.1 ±0.107
3 »	11	54.4 ±0.409	8.956±0.226	550±28	5.05±0.069	11	51.61±1.28	7.91±0.418	518 ±17	5.02±0.069
4 »	5	53.94	8.544	430	4.78	4	55.57±0.665	8.01±0.812	580	5.15
5 »	3	55.16	9.55	440	4.96	4	56	9.04	560	5.25
6 »	3	56.2	8.103	532	4.8	5	58.52	8.28	544	5.21
9 »	8	56.58±1.61	7.54 ±0.24	500±13.4	5.18±0.058	2	58.15	8.20	520	5.04
12 »	5	52.56	7.054	516	5.23	11	56.79±1.21	7.46±0.51	538 ±8	5.19±0.081
15 »	6	56.9	7.32	552	5.38	8	56.15±1.51	7.91±0.409	565 ±12.8	5.23±0.097
18 »	6	54.9	7.3	520	5.4	—	—	—	—	—
2 years (heifers)	20	55.85±0.876	6.72 ±0.286	561± 5.5	5.4 ±0.055	—	—	—	—	—
3 » (1st pregnancy)	8	57.06±0.82	6.45 ±0.25	542.4±11	5.56±0.056	—	—	—	—	—
3—5 years (cows)										
Healthy	48	54.93±0.63	6.35 ±0.103	549.6±11.2	5.71±0.047	—	—	—	—	—
Tubercular	8	59.68±0.96	6.107±0.108	510±21.6	5.63±0.089	—	—	—	—	—
6 years and over										
Healthy	23	53.7 ±0.83	5.57 ±0.12	554±15.2	5.82±0.043	—	Fully grown sires			—
Tubercular	38	56.13±0.77	5.75 ±0.116	503.2± 7.5	5.86±0.067	4	77.5	7.425	590	5.92

This is also confirmed by the study of the growth of calves which we have been able to make on the Uspenskaya farm.

The material of the present investigation enables us to throw some light on a question which so far has not been cleared up, namely, the effect which pregnancy has on the blood value of cattle. In Table 2 we give the blood value of cows in various stages of pregnancy.

Table 2

The Effect of Pregnancy on the Blood Value of Cows

Health and age of cows	Three months and under with calf					Five months and over with calf				
	Number of animals	Haemoglobin content	Number of erythrocytes	Alkalinity reserve	Diameter of erythrocytes	Number of animals	Haemoglobin content	Number of erythrocytes	Alkalinity reserve	Diameter of erythrocytes
Healthy:										
Born in 1921—31	18	53.4	5.52	554	5.82	5	54.7	5.72	550	5.84
» » 1932—35	38	54.28	6.30	540	5.69	10	57.59	6.51	580	5.84
Tubercular:										
Born in 1921—31	28	55.31	5.63	500	5.86	8	58.02	6.11	494	5.78

From this table one may draw the conclusion that cows in a more advanced stage of pregnancy have a higher haemoglobin content and a somewhat greater number of erythrocytes. We believe that the higher haemoglobin content of cows in an advanced stage of pregnancy is connected with the more intense metabolic process caused by the fact that the growing foetus develops a greater demand for oxygen.

Table 1 permits us to establish further a few regular principles regarding the effect of tuberculosis on blood value. The tubercular cows (tested for tuberculin) as compared with the healthy cows show a much higher haemoglobin content and a larger number of erythrocytes. We believe that this is the response of the part of the organism in its attempt to compensate the weakening function of the lungs by an increase in the oxygen carrying capacity of the blood through a higher haemoglobin content and a greater number of erythrocytes. The lower alkalinity reserve in the blood of tubercular cows is evidently connected with their reduced capacity to neutralize the toxic matter.

With the object of analyzing the relation between blood value and productivity, we have divided the cows into two groups as shown in Table 3. The first group comprises the record weight class; all the other cows were placed in the second group.

Thus, we see that cows of the higher class which are marked by a greater yield of milk and greater weight of body show a higher haemoglobin content and a greater number of erythrocytes. We believe that this relation between blood value and productivity is an evidence of the existence of a more general regularity, viz. that animals of a higher productivity have a more intensive metabolic process. In so far as the oxidative blood factors selected by us are closely connected with the metabolic process, it is natural enough that the animals which yield a higher productivity have shown a higher blood value.

Table 3

Difference in Blood Value of Yaroslav Cows of Different Classes of Productivity

Groups of animals	Number of animals	Body weight in kg	Milk yield (300 days)	Eurisome index*	Number of erythrocytes	Haemoglobin content	Alkalinity reserve	Diameter of erythrocytes
Healthy cows of 6 years and upwards:								
Record weight class	14	476	3 642	121	5.64	54.5	564.4	5.85
All other classes	7	402.7	2 980	119	5.32	51.6	520.0	5.80
Tubercular cows of 6 and 7 years:								
Record weight class	14	473	3 470	121	6.06	57.8	512	5.81
All other classes	5	398.6	3 206	116	5.42	55.8	536	5.90

In several of our previous works relating to sheep, cattle and camels ([2],[3],[4]) we have shown that, within the limits of uniform groups, animals with a higher blood value are usually heavier in weight. This is being confirmed by the material of the present investigation. As far as milk productivity is concerned, this material does not allow us to establish a connection between the yield of milk and haemoglobin content. Literary data available on the relation between blood factors and yield of milk are conflicting. While Storch ([10]) and Richter ([9]) maintain that there is a certain relation between them, Andreesen ([5]), McDay ([7]) and Kronacher ([6]), on the contrary, state that they have failed to establish any connection between them.

Table 4

Blood Value and Development of Calves, the Offspring of Various Sires

Groups of animals	Offspring of Dobryak 47							Offspring of Chijik 46						
	Number of animals	Haemoglobin content	Number of erythrocytes	Body weight				Number of animals	Haemoglobin content	Number of erythrocytes	Body weight			
				at birth	at 3 months	at 6 months	at 9 months				at birth	at 3 months	at 6 months	at 9 months
Born in 1937:														
Young female calves	6	54.68	9.28	30.8	76	—	—	12	48.56	8.5	29.2	74	—	—
Bullocks	12	53.5	8.58	32.3	85	—	—	7	48.35	7.99	29.6	75.8	—	—
Born in 1936:														
Young female calves	10	56.6	7.56	—	—	145	192.5	11	54.7	7.27	—	—	139.3	187
Bullocks	16	57	8.25	—	—	—	—	3	56	6.76	—	—	—	—

* The eurisome index represents the relation between the heart girth (just behind the elbow joint) and length of body from point of shoulders to ischium in percentage.

The herd of the Uspenskaya farm gave us interesting comparative material on blood value in relation to the development of the offspring of various sires. The principal sires of the farm are Dobryak № 47, a bull born in 1930, and Chijik № 46, born in 1929. The first showed a haemoglobin content of 83.3 according to Sahli and the second 66. 6. Table 4 gives the characteristics of their progeny born in 1936 and 1937.

We are thus entitled to conclude that the higher degree of development shown by the offspring of Dobryak is definitely related to their higher blood value. We should bear in mind that Dobryak shows a much higher haemoglobin content than Chijik. These data, provided they are confirmed by further investigations on a larger scale, tend to show that haematological investigations are of definite interest also for selection purposes.

Table 5 gives comparative figures relating to exterior and blood value of the Yaroslav and other breed which were investigated by us in 1936 at the Salsk experiment farm and also in Daghestan.

Table 5

Differences in Exterior and in the Functional Blood Capacity of Various Breeds of Cattle

Breeds	Body weight of adult cows	Eurisome index	L_{100}*
Highland (in Daghestan) .	154—187	115.0	153
Yaroslav	470	120.0	163.6
Kalmuck	427	119.4	177
Shorthorn	512	124.5	185
Hereford	568.7	126.2	191

From this table it may be seen that parallel with the rise in the eurisome index there is a rise in the blood value index (L_{100}). Inasmuch as the high eurisome index is a sign of a stronger constitition, while improvement of breed usually tends to raise still higher this index, we are inclined to believe that the higher oxidative capacity of the blood of the given breed of cattle is likewise a sign of the perfect constitution of this breed.

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* L_{100} is an index of the functional capacity of a haemoblogin surface of hundred cubic centimeters of blood calculated after the Goetze formula and is a product of the haemoglobin content and number and size of erythrocytes.

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PLANT PHYSIOLOGY

DEVELOPMENT OF THE LATEX VESSELS SYSTEM AS A FACTOR OF RUBBER ACCUMULATION IN KOK-SAGHYZ ROOTS

By S. J. RUDENSKAYA

(Communicated by N. I. Vavilov, Member of the Academy, 3.VI. 1938)

One of the most important conditions determining rubber yield of kok-saghyz is the degree of development of the latex vessels which are the only receptacles of rubber in kok-saghyz roots.

The main object of our work was to find out what are the conditions that will secure the formation of the best structural characters of kok-saghyz roots, and, consequently, result in the highest rubber production.

This task necessarily implies a detailed study of the fundamental regularities underlying the course of development of the latex vessel system in kok-saghyz, in connection with growth and development of the plant as a whole. Such a study would finally give an idea as to the possibility of controlling this development and profiting of it.

A number of anatomical investigations of kok-saghyz plants (1) show their root to have a regular anatomical structure, involving a central cylinder of xylem, a regular cambium and a circle of secondary bark, the development of the latter surpassing that of wood.

The diameter of the central xylem cylinder of annual roots is equal to $^1/_6$—$^1/_7$ of the total root diameter. The latex vessels are distributed in the secondary bark forming concentrical circles. Within each circle the vessels are in communication with each other which is achieved by means of anastamoses, forming a closed network, while there exists no communication between separate circles. Thus, the system of latex vessels presents a kind of reticulate cylinders inserted into one another and separated by several layers of cells of bark parenchyma.

Our observations of the development of latex vessels cover the period from the complete rosette-stage to the end of the first year of vegetation. As experimental material were used plants sown in the spring of 1937 on the experiment station of the Scientific Institute of Rubber and Gutta-Percha. During the vegetation period were made 5 tests, each of them including 100 plants. Records were effected on cross-sections, treated after the bromation method (2).

The following results were obtained.

1. The number of circles of the latex vessels increase with the growth of the root. With the formation of new layers of bark tissue cells each circle of vessels recedes towards the periphery, thus augmenting both diameter and length of the circle.

Table 1

Date of record (month)	VI	VII	VIII	IX	X
Number of circles of latex vessels .	3.7	9.07	12.74	14.95	14.80
Radius in mm	0.61	2.08	2.87	3.26	3.20

2. Latex vessels are differentiated from daughter cells of cambium, in the immediate vicinity of the latter. The number of latex vessels within each separate circle is determined during a short period following the moment of differentiation, and remains more or less constant till the end of the vegetation period.

3. During the first months of intensive development the total number of latex vessels prove to be larger within «younger» circles, than within those of earlier formation. This points to the fact that the intensity of the process of cell differentiation into latex vessels is gradually increasing at a definite period.

The statements made in paragraphs 2 and 3 are illustrated by the figures of Table 2, obtained from a calculation of the latex vessels within the individual circles 1,3,7 and 10, counting from the periphery in the sequence of their formation.

Table 2

Date of record (month)	Total number of latex vessels within 1/4 of circle area				Note
	Circle 1	Circle 3	Circle 7	Circle 10	
VII	22	47	67	—	Circle 7 was formed only in July, circle 10—early in August. By the time of the July and August harvest those circles occupied approximately the third place from cambium
VIII	34	50	65	75	
IX	27	49	63	66	
X	27	49	57	59	

Each of the vertical columns seems to have a definite character in spite of some deviation within the column. Thus, all the figures of the first column (1st circle) are lower than those of other columns; the figures of the second column (3rd circle) are lower than those of the third and fourth columns, and so on. The third and fourth columns (7th and 10th circles) are rather similar.

Table 3

Date of record (month)	Number of latex vessels within a section 1 mm long			
	Circle 1	Circle 3	Circle 7	Circle 10
VI	19	55	—	—
VII	7	17	46	—
VIII	7	13	24	46
IX	5	11	22	36
X	6	11	20	34

This may be explained by the fact that the intensity of the differentiation of cells into latex vessels went on increasing in the course of the vegetation process. Since August the rate of the cell differentiation becomes stable,

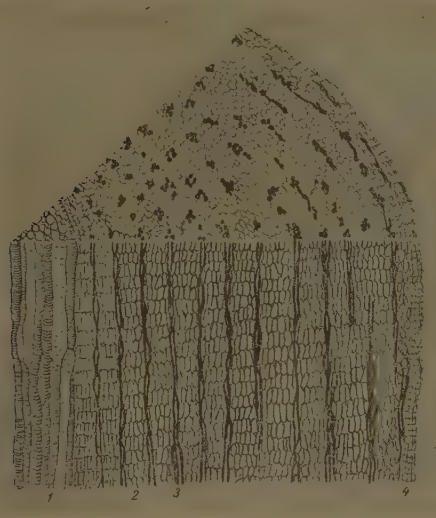

Fig. 1. Anatomical structure of a kok-saghyz root. *1*—wood, *2*—parenchyma, *3*—latex vessels, *4*—bark.

and the number of latex vessels within the circles formed during the later months does not exceed that contained in the preceding circles.

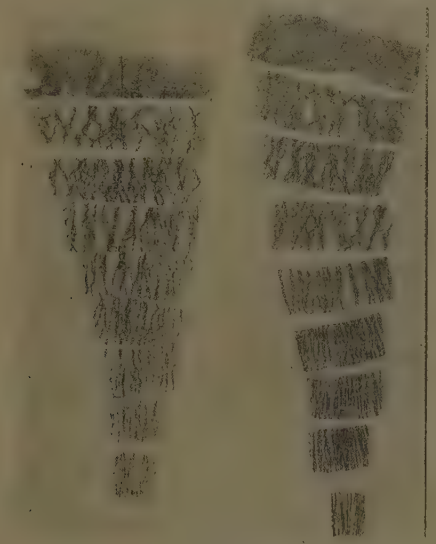

Fig. 2. Preparations were made by separating concentrical circles of the latex vessels in the same order they were distributed in the root.

Thus, June, July and the half of August were the months when the most intense formation of latex vessels was observed.

4. As the root is growing, the given circle recedes to the periphery, suffering at the same time some expansion (Fig. 2). The number of latex vessels per 1 mm of circle length decreases markedly. An especially sharp drop is observed during the first month following the formation of the circle. Later on the curve of the drop is smoothed out.

Such an expansion of the circles of latex vessels ultimately results in a general dispersion of the vessels and in a reduction in number per unit of the area of root cross-section, which may be seen from the data of Table 3a.

Table 3a

Date of record (month)	VI	VII	VIII	IX	X
Average number of latex vessels per 1 mm^2	288.0	114.0	88.7	85.2	84.3

This unfavourable circumstance in the development of latex vessels is, however, compensated by a number of favourable changes, the most important of which consists of a relatively intense growth of the diameters of latex vessels and, consequently, of the total area of the cross-section of the root.

Table 4

Date of record (month)	VI	VII	VIII	IX	X
Average area of latex vessels in μ^2 .	72.25	199.95	225.79	338.96	362.86
Area of cross-sections of latex vessels in % to the total area of the root cross-section	2.07	2.27	2.00	2.88	3.04
Relative area	1.0	1.09	0.96	1.39	1.46

Thus, the relative capacity of the system of latex vessels increases in proportion to the total volume of the root.

This fact points to a probable rise of rubber yields with the age of the plant which we practically use to observe.

Table 5

Date of record (month)	VI	VII	VIII	IX	X
Rubber content in % to dry mass (extraction method)	1.89	4.38	4.45	6.81	6.98
Relative	1.0	2.31	2.35	3.60	3.69

However, the content of rubber in the roots increases at a considerably higher rate than the capacity of the latex vessels as compared with the total volume of the root, which may be seen from the comparison of Tables 4 and 5.

This may be accounted for by the increase of rubber amount filling the latex vessels, or, which is about the same, by a hightened rubber concentration in the latex.

In fact, data as to the volume of latex vessels in definite root sections and their absolute rubber content exhibit a rather sharp growth of the filling of latex vessels with rubber.

Table 6

Date of harvest (month)	VII	VIII	IX	X
Absol. amount of rubber in g per 1 cm³ of latex vessels capacity*	0.62	0.74	0.95	1.03
Relative rubber amount	1.0	1.19	1.53	1.66

The above data permit of the following conclusions to be drawn.

1. In connection with kok-saghyz development and the growth of its roots during the vegetation period increase both the number of circles in the roots and the total number of latex vessels. At the same time, however, takes place the dispersion of latex vessels (reduction of the number of latex vessels per unit root cross-section area), owing to the growth of interstices between the latex vessels within each separate circle.

2. The relatively rapid growth of the diameter of latex vessels results in an increased volume as compared with that of the root; the latex concentration increasing at the same time, a steady growth of the total rubber yield of the root is established.

3. Thus, kok-saghyz plants develop till the late autumn the following economically valuable characters:

a) ratio of rubber, and, consequently, its absolute content;

b) diameter of latex vessels, which facilitates the procedure of rubber extraction in the form of latex after the method of washing (according to the formula of Poiseuil, the rate of outflow of liquids from capillaries is proportional to the 4th degree of the ratio of their radii);

c) concentration of latex, facilitating its subsequent treatment during extraction;

d) the development of economically valuable characters proceeds till the late autumn, i. e. up to a later season than that when digging is usually performed. The revision of the dates of digging should, therefore, be urged, so much the more as it is connected with the character and course of qualitative changes taking place in rubber and resins.

4. The only unfavourable character connected with the thickening of the root is the dispersion of latex vessels, which is the more conspicuous, the more intensely proceeds the growth of the root (its thickening). Our next task is, therefore, to make clear the conditions securing the most intense process of cell differentiation into latex vessels which would essentially reduce the effect of this disadvantageous tendency.

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* Measurements of latex vessels capacity were made on material fixed with alcohol. They do, therefore, reflect but the mere tendency of latex vessels to augment their rubber content, without pretending to give a full idea of the absolute rubber content per unit of the volume of live latex vessels.

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PLANT PHYSIOLOGY

RELATION BETWEEN THE STRUCTURE OF TISSUES AND COLD RESISTANCE

By A. F. BIBIKOVA

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The abundant literary data on the causes of cold resistance of tissues justify the conclusion that resistance of the plant organism depends on many circumstances both internal and external. At the present time it is established that the study of cold resistance should not be limited to changes that occur in plant tissues during the autumn and winter periods; the works by Moshkov ([1],[2]), have shown that the change of the photoperiodic action in the course of the growth period on the background of temperature conditions influences the ability of tissues to withstand low temperatures.

Numerous investigations which have been conducted in order to study cold resistance touch upon a series of physiological processes, many of which have as yet received no adequate interpretation (enzymatic processes, respiration, etc.). Still less studied is the anatomical structure of plants which differ in resistance.

In order to make clear the anatomical structure of fruit trees in connection with their cold resistance, different varieties of apples, apricot, peach and cherry were studied.

Samples from 8 trees of each variety* were taken in order to secure the mean values. The degree of cold resistance was determined on the basis of field observations in large plantations of the Krasnodar region (recording injuries that followed cold winters) and according to literary data available. As cold resistant varieties of apples were taken: Astrakhanskoe beloe, Astrakhanskoe krasnoe, Borovinka; from the non-resistant varieties were employed Reinette de Champagne, Prize-Wagner and Reinette Simirenko.

The results of anatomical investigations presented below (the mean values were obtained through measurements of 1500 cells and 200 stomata) show a connection between the structure of the leaves and cold resistance. On the basis of the data obtained the conclusion may be drawn that the cold resistant varieties of apples possess larger cells in their leaves, and that this regularity is manifested both in young and in old trees. The difference in the cell size is particularly clear when varieties are compared which widely differ from each other with regard to the degree of cold resistance. Comparison of the sizes of anatomical elements of the leaves of young trees (of 7—8 years of age,

* Varieties to be compared were of identical age and origin. They were identically treated (Sovkhoz «Sad Gigant», Slaviansk Region, Sovkhoz «Sadzentrest», Krasnodar region).

Table 1

Mean Values of the Anatomical Elements of Leaves
(Samples Taken from Young Trees in the Region of Krasnodar)

Varieties	Degree of cold resistance	From vegetative branches			From fruit producing branches
		Length of stomata*	Length of cells	Area of cells	Area of cells
Astrakhanskoe beloe	1	25.0	31.0	4.815	4.992
Astrakhanskoe krasnoe	2	24.8	30.1	4.385	3.989
Borovinka	—	24.3	29.9	4.158	4.418
Rose-Mary white	3	23.0	28.2	3.730	3.971
Winter golden Parmen	4	22.2	27.7	3.681	3.875
London Pepin	5	22.1	26.1	3.195	3.111
Reinette de Champagne	6	20.6	25.5	3.155	3.005
Prize-Wagner	7	20.3	24.4	2.710	2.980
Reinette Simirenko	8	19.9	22.7	2.427	2.845

Table 2

Mean Values of the Anatomical Elements of Leaves
(Samples Taken from Young Trees in the Slaviansk Region)

Varieties	Degree of cold resistance	From vegetative branches			From fruit producing branches
		Length of stomata	Length of cells	Area of cells	Area of cells
Rose-Mary white	3	23.2	30.6	4.485	4.738
Winter golden Parmen	4	22.5	29.3	4.081	4.451
London Pepin	5	21.1	27.1	3.366	3.031
Reinette de Champagne	6	20.6	25.6	3.173	3.052
Prize-Wagner	7	20.0	24.7	2.796	2.653
Reinette Simirenko	8	19.9	23.1	2.539	2.677

Table 3

Mean Values of the Anatomical Elements of Leaves
(Samples Taken from Old Trees in the Krasnodar Region)

Varieties	Degree of cold resistance	From vegetative branches		From fruit producing branches
		Length of stomata	Area of cells	Area of cells
Astrakhanskoe beloe	1	24.5	3.875	3.918
Astrakhanskoe krasnoe	2	24.4	3.366	2.995
Rose-Mary white	3	22.7	3.285	3.418
Reinette Simirenko	8	19.8	2.331	2.417

* Dimensions of the cells and of the stomata are expressed in values obtained through measurements in the projective field of the microscope (objective Leitz 8, Zeichenokular E. Leitz Wetzlar, dimension in mm, area in cm^2).

Table 4

Mean Values of the Anatomical Elements of Leaves
(Samples Taken from Old Trees in the Slaviansk Region)

Varieties	Degree of cold resistance	From vegetative branches		From fruit producing branches
		Length of stomata	Area of cells	Area of cells
Rose-Mary white	3	21.9	3.079	3.117
London Pepin	5	20.8	2.911	2.836
Reinette de Champagne	6	20.0	2.892	2.740
Reinette Simirenko	8	20.0	2.471	2.583

Tables 1 and 2) with those determined for the older trees (about 30 years, Tables 3 and 4) shows that a decrease of the size of cells and stomata takes place with the age. Such a decrease of the size of cells and stomata is, possibly, connected with a change to the worse in the water supply in older trees, this change being reflected on the structure of the leaves. The results of an anatomical study of the leaves in apricot, peach and cherry have shown no definite relation between the sizes of the leaf elements and cold resistance. Thus, the apricot (variety Krasonoščekiy) which is considerably less resistant than the cherry (variety Vladimirskaya) possessed very large cell dimensions. The lack of connection between the leave structure and the cold resistance when different kinds of fruit trees are compared justifies the suggestion that the above-noted correlation should be limited only to varieties, different with regard to resistance but belonging to one and the same kind. Differences in anatomical structure between varieties differing in resistance were discovered not only in the leaf structure, but also in the structure of shoots which were investigated during the winter time. Comparison of the size of vessels* has shown that those varieties which possess the maximum size of vessels are distinguished by higher resistance. This difference in the water-conducting channels may, possibly, influence the water supply to leaves during the growth period. Some confirmation of this statement was found in the comparison of the water deficit in the leaves in varieties, differing in the size of vessels (when vessels are large, the deficit is less). The lack of sufficient data makes it impossible to draw a general conclusion regarding the significance of the water-conducting channels for the change in the water content in leaves; the existence of such a connection, however, is not excluded. Variation in water-supply is intimately connected with such processes as assimilation, and may influence the structure of the leaves ([3],[4]); the latter statement is supported by the fact that leaves of older trees are composed of smaller cells. An anatomical study of branches disclosed in more resistant varieties also larger dimensions of cells of wood, bast and pith. The difference in anatomical structure of branches of apple-trees was established in 5 varieties; a demonstration of the universality of this phenomenon through farther study would be of interest with regard to certain physiological processes. Differences in the process of respiration during the winter period, in the accumulation of CO_2 in cold resistant and non-resistant varieties of apples ([5],[6]), may be to a certain extent connected with the oxygen supply which is, possibly, different in small-celled and large-celled tissues.

* The means were derived from the measurements of 300 vessels.

Table 1

Mean Values of the Anatomical Elements of Leaves
(Samples Taken from Young Trees in the Region of Krasnodar)

Varieties	Degree of cold resistance	From vegetative branches			From fruit producing branches
		Length of stomata*	Length of cells	Area of cells	Area of cells
Astrakhanskoe beloe	1	25.0	31.0	4.815	4.992
Astrakhanskoe krasnoe	2	24.8	30.1	4.385	3.989
Borovinka	—	24.3	29.9	4.158	4.418
Rose-Mary white	3	23.0	28.2	3.730	3.971
Winter golden Parmen	4	22.2	27.7	3.681	3.875
London Pepin	5	22.1	26.1	3.195	3.111
Reinette de Champagne	6	20.6	25.5	3.155	3.005
Prize-Wagner	7	20.3	24.4	2.710	2.980
Reinette Simirenko	8	19.9	22.7	2.427	2.845

Table 2

Mean Values of the Anatomical Elements of Leaves
(Samples Taken from Young Trees in the Slaviansk Region)

Varieties	Degree of cold resistance	From vegetative branches			From fruit producing branches
		Length of stomata	Length of cells	Area of cells	Area of cells
Rose-Mary white	3	23.2	30.6	4.485	4.738
Winter golden Parmen	4	22.5	29.3	4.081	4.451
London Pepin	5	21.1	27.1	3.366	3.031
Reinette de Champagne	6	20.6	25.6	3.173	3.052
Prize-Wagner	7	20.0	24.7	2.796	2.653
Reinette Simirenko	8	19.9	23.1	2.539	2.677

Table 3

Mean Values of the Anatomical Elements of Leaves
(Samples Taken from Old Trees in the Krasnodar Region)

Varieties	Degree of cold resistance	From vegetative branches		From fruit producing branches
		Length of stomata	Area of cells	Area of cells
Astrakhanskoe beloe	1	24.5	3.875	3.918
Astrakhanskoe krasnoe	2	24.4	3.366	2.995
Rose-Mary white	3	22.7	3.285	3.418
Reinette Simirenko	8	19.8	2.331	2.417

* Dimensions of the cells and of the stomata are expressed in values obtained through measurements in the projective field of the microscope (objective Leitz 8, Zeichenokular E. Leitz Wetzlar, dimension in mm, area in cm²).

Table 4

Mean Values of the Anatomical Elements of Leaves
(Samples Taken from Old Trees in the Slaviansk Region)

Varieties	Degree of cold resistance	From vegetative branches		From fruit producing branches
		Length of stomata	Area of cells	Area of cells
Rose-Mary white	3	21.9	3.079	3.117
London Pepin	5	20.8	2.911	2.836
Reinette de Champagne	6	20.0	2.892	2.740
Reinette Simirenko	8	20.0	2.471	2.583

Tables 1 and 2) with those determined for the older trees (about 30 years, Tables 3 and 4) shows that a decrease of the size of cells and stomata takes place with the age. Such a decrease of the size of cells and stomata is, possibly, connected with a change to the worse in the water supply in older trees, this change being reflected on the structure of the leaves. The results of an anatomical study of the leaves in apricot, peach and cherry have shown no definite relation between the sizes of the leaf elements and cold resistance. Thus, the apricot (variety Krasnoščekiy) which is considerably less resistant than the cherry (variety Vladimirskaya) possessed very large cell dimensions. The lack of connection between the leave structure and the cold resistance when different kinds of fruit trees are compared justifies the suggestion that the above-noted correlation should be limited only to varieties, different with regard to resistance but belonging to one and the same kind. Differences in anatomical structure between varieties differing in resistance were discovered not only in the leaf structure, but also in the structure of shoots which were investigated during the winter time. Comparison of the size of vessels* has shown that those varieties which possess the maximum size of vessels are distinguished by higher resistance. This difference in the water-conducting channels may, possibly, influence the water supply to leaves during the growth period. Some confirmation of this statement was found in the comparison of the water deficit in the leaves in varieties, differing in the size of vessels (when vessels are large, the deficit is less). The lack of sufficient data makes it impossible to draw a general conclusion regarding the significance of the water-conducting channels for the change in the water content in leaves; the existence of such a connection, however, is not excluded. Variation in water-supply is intimately connected with such processes as assimilation, and may influence the structure of the leaves ([3],[4]); the latter statement is supported by the fact that leaves of older trees are composed of smaller cells. An anatomical study of branches disclosed in more resistant varieties also larger dimensions of cells of wood, bast and pith. The difference in anatomical structure of branches of apple-trees was established in 5 varieties; a demonstration of the universality of this phenomenon through farther study would be of interest with regard to certain physiological processes. Differences in the process of respiration during the winter period, in the accumulation of CO_2 in cold resistant and non-resistant varieties of apples ([5],[6]), may be to a certain extent connected with the oxygen supply which is, possibly, different in small-celled and large-celled tissues.

* The means were derived from the measurements of 300 vessels.

Determinations of the chemical composition of the branches of apple-trees and of the peech (during the winter rest) which were made parallel to the anatomical study, have supplied no indications that the total amount of carbohydrates as well as individual forms of the latter may serve as indices of the varietal resistance; thus, for instance, the total amount of carhohydrates was found to be in Astrakhanskoe krasnoe 15.2%, in Rose-Mary white—11.42%, in Reinette Simirenko—14.49%, and in the Amsden peach—15.03%. It may be noted that only with regard to the total amount of sugars the most resisstant varieties (Astrakhanskoe beloe, Borovinka, Astrakhanskoe krasnoe) were the somewhat richer ones. However, there was no strict regularity in the connection with the degree of varietal resistance either. Determination of the concentration of the cell sap (by means of the refractometrical method) which was conducted in the autumn and winter periods (August 25, November 25, December 10, December 31, January 25, February 5). showed a general increase in concentration during the winter time, while it failed to discover any regular connection with the resistance of the varieties.

Conclusions

1. There exists a relation between the structure of the leaves and the cold resistance in apple-trees: the cold resistant varieties are distinguished by larger cells and stomata. This relation is observed in various conditions of growth and at various ages of the trees. Comparison of different kinds of fruit-trees showed no correlation between the cold resistance and the leaf structure. A difference in the anatomical structure of branches in cold resistant and non-resistant varieties was noted.

2. Concentration of the cell sap as well as starch, dextrine and hemi-cellulose gave no correlation with resistance; only in the case of the total amount of sugars a certain increase was discovered in the most resistant varieties.

It is of great practical interest to clear up the possibility of employing differences in anatomical structure for the purposes of breeding new cold resistant forms.

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41

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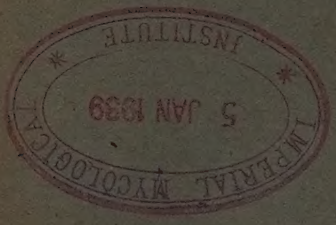
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